

# **Development of a universal enterprise model for multi-country manufacturing systems analysis**

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## **Declaration**

I, Sekhar N Chattopadhyay, hereby declare that the PhD thesis entitled “Development of a universal enterprise model for multi-country manufacturing systems analysis”:

- a) Except where due acknowledgement has been made the work is that of the candidate alone;
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Date

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## Thesis Abstract

The shortcomings of the existing Enterprise Architectures (EAs) observed during the field studies in Australia, China and India is the primary motivation for this research to look for new EA's that address complexities of 21<sup>st</sup> Century organisations. Each organisation is unique in its own way. A universal enterprise model should therefore capture the commonalities at the core and provide the flexibility to allow differences to exist. EA's are fundamentally driven by the People and their sphere of influence. This thesis presents five such different micro-architectural views (sometimes called sub-models) of EAs and integrates them into a macro-architecture with the given name – “Pentatomic Organisations” that can be used to describe enterprises in the 21<sup>st</sup> century universally. These five micro-architectural views are unified and universal with People, as unique entity, in their core that manifests different attributes and characteristics to the organisations. Pentatomic organisations (PO's) have a simple, flexible and dynamic EA understood by, and can be communicated to, all in the organisation using common language. A strategy driven organisation creates, maintains, improves and/or decommissions an enterprise during its lifecycle phases for governance and to satisfy its customers. The first and the foremost micro-architectural view of the PO is the People-Centric Model (PCM) that recognises the pervading presence of people at all levels of the organisation irrespective of their roles, functions and relationships. This sub-model has got a layered and flexible architecture pivoted on people skills flanked by resource and information on either side. The EA in PCM is coupled to a closed-loop feedback system with customer and strategy. The second micro-architectural view in PO is the Molecular Model (MM). It describes how individual outputs are created by combining skills, resources and information. By drawing an analogical comparison between humans to atoms this sub-model shows how a human atom interacts with another in a business transaction. The third sub-model is the Kaizen-Lean Six Sigma Model (KLSSM). This micro-architectural view demonstrates how ‘Continuous Improvement’ as a philosophy is so vital for any organisation intending to survive under the turbulent business environment today. The fourth micro-architectural view is the Globally Dispersed Model (GDM). This micro-architectural view represents the typical features of a truly geographically dispersed manufacturing outfit in a globalised world. This sub-model also subscribes to the principles of a human-centered and eco-friendly approach to addresses sustainable manufacturing. The fifth and the last micro-architectural view is the Disaggregated Value Chain Model (DVCM). It describes how a value chain is getting

disaggregated into a human network of networks in a flat world today. It also demonstrates how individual sphere of influence interacts in a dynamic business environment. The thesis also provides a process by which an industry, manufacturing or service, may choose to adopt any of the five new EA micro-architectural views, or a combination thereof to address and embrace change that is inevitable in today's business environment. The Pentatomic Organisation EA could help industries to "sense and respond" to complex external business environment as a vehicle to change roles and functions of the people, and allocate timely resources to them utilising information/data driven decision making process in lightning speed.

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# **Chapter 1      Introduction**

## **1.1 Scope of Research**

In the last decade, global economy scenario has changed significantly. Many business reports show that China and India are growing at double digit growth rate (India 10.4% to China's 10.3%) as compared to economic downturn in many developed countries (Lavine, 2011). Goldman Sachs report on Brasil, Russia, India and China (BRIC) recognises this. However there is also a criticism of this report that the BRIC projections are based on the assumptions that resources are limitless and endlessly available when needed (Sapovadia, 2010). Many theories have been proposed but none was able to suggest useful changes that can assist Australian companies to be competitive against these new economies. To find an answer to this question, one needs to understand and investigate their enterprises and develop an appropriate model that can point to the fundamental issue.

Enterprise modelling is the underlying science representing the structure and behaviour of a business entity. The enterprise model usually consists of several sub-models that have user-oriented meta-knowledge structures for communication with human sources of information. The success of the methodology in different areas depends on its representative and explanatory capabilities. These sub-models are used to describe the same enterprise from different viewpoints. Due to the complexity of models handled (both in terms of number of components and their relationships existing among components), a modular and incremental modelling approach is often recommended. Most modelling languages use a building block approach and support the definition of partial models (i.e. libraries of partly assembled building blocks). In the past decade many researchers have developed Reference Models which are based on strong engineering disciplines using partial models to build a highly sophisticated enterprise system. These researches have resulted in the international standard ISO 15704 GERAM (Generic Enterprise Reference Architecture and Methodology).

There are three types of reference models in enterprise engineering: (i) abstract models (fill-in-the-blank); (ii) paradigmatic models (can be modified or adapted to particular industry); (iii) specific models (company specific constructs). Models developed for computer

integrated manufacturing enterprises usually belong to type (i) (Bernus, 2001). Engineering and consulting companies build up their own 'model libraries' and they are typical type (ii) reference models (Noran, 2003b). A rather large 'space' of possible enterprise models is type (iii) which is applicable to most business organisations (Kalpic et al, 2005). Within this space each individual model is potentially different, due to differences in operations, business practices, country specific issues, culture and other factors. Therefore, to investigate the success factors of Indian and Chinese enterprises against those in Australia, enterprise modelling methodology will have to undergo substantial research to a more mature discipline, where the design of complex enterprise systems will be based on universal component based modelling and configuration.

Enterprise modelling is receiving growing attention as an engineering technique to better represent and form the basis to assist restructuring of enterprise operations effectively. It is an important decision support tool for anticipating and managing change in an on-going evolution cycle of enterprise development (Berio and Vernadat, 1999). Choi et al (2008) found that when the inter-enterprise business processes in a value chain are required and the agreement on common business processes is a prerequisite for collaboration, only high level of business processes is worth considering. They proposed a data reference model as separated from business process reference models. Doumeingts and Ducq (2001) presented three enterprise modelling methods: GIM for re-engineering, GIMSOFT for the choice of an ERP and ECOGRAI for design and implementation of KPIs. Leger and Morel (2001) proposed a formal enterprise framework for understanding all actors involved in a proactive maintenance strategy implementation. Camarinha-Matos and Afsarmanesh (2003) presented an overview of current approaches and trends towards various example architectures from several international research projects. None of them addressed the issue of comparative modelling in a multi-countries context.

According to Bernus (2003) partial models are essentially templates that can be reused but agreed that a validation process would modify and enrich the partial model. Measures for controlling the quality of processes can therefore be identified by using and reusing enterprise models. Harding et al (2006) suggested a novel approach of utilizing existing enterprise reference architectures, integration and modelling frameworks by the introduction of new enterprise views such as mining and knowledge views. Noran (2005) suggests that partial models can be built by specialising generic models and validating them via several

good particular models obtained by instantiating the partial model. These researches paved the way for more flexible modelling constructs that can adapt to larger variations between enterprise models. Unfortunately, the studies were focussed at abstract levels and could not be used for building real enterprise models.

Canavesio and Martinez (2007) presented a conceptual model for small and medium enterprises (SMEs) networking based on the fractal company approach and concepts like projects, resources, goals, specialized actors, plans and relationships thereof. Gunasekaran and Ngai (2007) highlighted that without the integration of people and information technology/information systems (IT/IS), it was hard to achieve any significant improvement in organizational performance. Hsu and Hsu (2008) proposed a systematic and hierarchical approach consisted of top-down modelling and bottom-up implementation steps suitable for developing the resource planning system (RPS). These researches were commendable for inter-enterprise analysis and could form the basis for investigating international collaboration between countries at different state of development and growth.

This research is built on the traditional enterprise modelling approach and extends into the unanswered issues of comparative modelling with foreseeable differences influenced by social, economical, business processes and country specific factors. The author creates flexible enterprise models that are universally acceptable in different countries so as to achieve realistic and meaningful models. By developing a new enterprise modelling methodology that is not affected by country specific bias factors, the model characteristics that Australian industries would need to adapt to remain globally competitive and to synchronise their enterprise capabilities with their counterpart in China and India can be highlighted.

## **1.2 Objectives**

This research aims to investigate a universal set of benchmarking enterprise models that will allow comparative enterprise practices, structures and work cultures between Australia, India and China.

The research has the following objectives:



1. Develop a universal enterprise modelling methodology for manufacturing system analysis
2. Evaluate the commonalities and differences between these country-specific reference models in Australia, China and India.
3. Discover qualitative models characteristics (not under different environments) that could be adapted to Australian industries to make them more competitive in the global market.
4. Establish the operational models to work effectively across businesses in multi-country locations.

The outcome of this research is the theory for supporting cross cultural enterprise modelling methodology that can be used to create comparable models for enterprises from different countries. In particular, the models are applicable to modelling Australian, Indian and Chinese companies for the specific purpose of this research, that is, to compare the differences between companies operating in these countries and highlight the characteristics that Australian enterprises can be re-designed to remain competitive against companies from other countries.

### 1.3 Research Plan

The research methodology as adopted in this research is a pragmatic approach that includes a combination of the development of theoretical modelling methods with the enterprise case studies conducted in Australia and overseas. In view of the problems with the existing Enterprise Architectures (EA's) it became necessary to investigate current status on uptake of existing EA usage by industries and associated problems thereof.

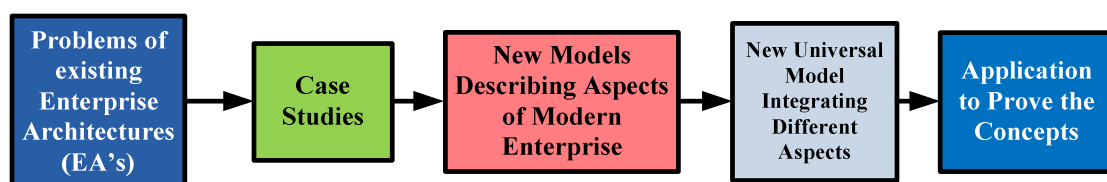


Figure1.1 Approach to solve the problems

Accordingly a number of case studies were first undertaken in Australia. In order to enlarge the scope of investigation similar case studies were also undertaken in China and India. The objective was to study and compare multi-country EA usage.

	<b>Title of Activity</b>	<b>Activity description &amp; Relation to Research Questions</b>
1.	Literature review	Survey available enterprise modelling methodologies and develop the research proposal. Based on the findings, a preliminary universal enterprise modelling framework is developed.
2.	Evaluate modelling framework	Work visits, literature review and model creation to identify characteristics for local companies.
3.	Modelling of Australian companies	Negotiate arrangements for visiting Australian companies to carry out Enterprise Architecture Mapping (EAM). Develop The local enterprise model (M1). This task will provide practise of the universal modelling framework and allow refinement of the theoretical framework.
4.	Visit India and China to study country specific enterprise models	Characterise differences in enterprise processes and structures to analyse and assess how the enterprise architecture of companies in other countries are designed and operated. This study provides the information for developing M2 and M3. In addition, the study will also investigate how international consortia operate under diverse business and cultural backgrounds.
5.	Characterise and compare enterprise models M1, M2 and M3	All the enterprise models and company data are available. This task will carry out research data analysis and interpretation. The enterprise models M1, M2 and M3 are systematically compared and the differences are mapped.
6.	Improve enterprise models for Australian industries	The comparative study for all models will highlight the advantages and deficiencies of Australian enterprise models. By benchmarking and adaptation, conclusion can then be made on the improvements that Australian companies should adopt in order to become competitive globally.
7.	Evaluate improved enterprise modelling framework	Continue literature review. Fine-tune the theoretical framework to incorporate unforeseeable attributes and modelling irregularities. The models M1, M2 and M3 are refined to identify methods for collaboration with overseas partners.
8.	Write thesis and papers	Publish the findings in the research in journals and refereed conferences. Write the thesis.

Table 1.1 Research plan

The research outcome of these case studies resulted in conceptualising the new theoretical models that characterised the key aspects of the 21st century organisations. These new

models (sub-models) reflecting different aspects of enterprises were subsequently integrated in an endeavour to develop a universal model and to apply it back to the industries where case studies were initially conducted Figure 1.1.

The research plan has been designed to investigate enterprise models of Australian industries in the first year of research. In the second year, work visits and in-depth study tours were undertaken to India and China to apply the same modelling methodologies for companies in those countries. Consolidating upon the data as was obtained from the study tours, the enterprise models are compared and country specific characteristics can be identified.

The research plan was divided into eight main tasks Table 1.1.

There are only three internationally recognised enterprise reference architectures and they are CIMOSA, PERA and GRAI-GIM. GERAM is not new reference architecture as such. The reasons for not recognising others such as IEM, ARIS and Zachman and so on are not explicitly referred by any researchers hence not referred

## **1.4 Structure of the Thesis**

Chapter 1 provides the project background, objective and research plan and the rest of the thesis comprises of ten chapters with two appendices at the end.

Chapter 2 discusses latest contributions made by various academics and researchers till date. Related citations have been classified and grouped together under separate sections so that a correlation between the literature review and the newly developed models could be easily established. Chapter 3 discusses the theory and development of a new People-Centric Model (PCM) where role of people skills, resources and information have been defended as the foundation of this research. In order to extend the PCM into micro-architectural level another new model Molecular Model (MM) became necessary which has been discussed in Chapter 4. Continuous improvement as a philosophy is indispensable for all enterprises. Chapter 5 discusses the integration of Kaizen into lean-six sigma during the operation phase of the enterprise lifecycle in Kaizen Lean Six Sigma Model (KLSSM). Enterprises in the 21<sup>st</sup> century are globally integrated but geographically dispersed which is represented by

another new model Globally Dispersed Model (GDM) in Chapter 6. Large corporations are disaggregating their value chain into small autonomous units to gain competitive advantage which is discussed in Chapter 7 on the Disaggregated Value Chain Model (DVCM). These five newly developed models are unified under a federated structure Pentatomic Organisation Model (POM) in Chapter 8. Chapter 9 discusses the comparative merits and demerits of the various models and conditions for their application to industries. Finally Chapter 10 draws a conclusion based on the research findings of this thesis and gives an overview on future research. Appendix - I at the end provides details of the various companies in Australia, China and India where case studies were conducted and Appendix - II lists out the publications till date.

## **1.5 Research Methodology**

As inductive research methodology has been followed in this thesis. The primary purpose of the inductive approach is to allow research findings to emerge from the frequent, dominant or significant themes inherent in raw data, without the restraints imposed by structured methodologies. Key themes are often obscured, reframed or left invisible because of the preconceptions in the data collection and data analysis procedures imposed by deductive data analysis such as those used in experimental and hypothesis testing research.

The following are some of the purposes underlying the development of the general inductive approach. These purposes are similar to other qualitative analysis approaches.

- To condense extensive and varied raw text data into a brief, summary format.
- To establish clear links between the research objectives and the summary findings
- To ensure these links are both transparent and defensible.
- To develop model or theory about the underlying structure of experiences or processes

## **Chapter 2      Literature Review**

### **2.1 Overview**

According to Child and Tse (2001) all industrial nations of the world are alarmed with the significant economic and technological rise of the two upcoming superpowers China and India with an annual average GDP growth rate between 2000 and 2010 at 10.1% and 7.3% respectively. In addition both these countries possess their own huge domestic markets. The world has been witnessing a sharp geopolitical and commercial polarisation in the landscape of manufacturing.

For 2010, the IMF is forecasting that Australia's GDP will grow by 3.0% (International Monetary Fund, 2010). The developing Asian nations, led by China and India, are forecast to remain the strongest performing group in terms of economic growth in coming years, ensuring ongoing demand for Australia's exports. Historically Australia has its economic, political and social ties with the West in particular Europe and North America despite its geographical location closer to the South East Asia (Power and Sohal, 2000). A continent in size Australia is rich in natural resources such as minerals and so on. Australia's population is very low characterized by lower domestic consumption as compared to China and India. Threats from China and India as posed to the rest of the world are due to availability of local knowledge workers at significantly lower costs compared to the developed nations in the West, cheaper raw materials and service costs (Luo, 2003). This has put Australia in the middle of a cross road especially in manufacturing. Australia, however, witnesses many challenging opportunities on the other end of the tunnel (Metters and Verma, 2008).

Despite all fanfare about China and India in recent times both countries suffer from adverse international propaganda in terms their track record in quality, infrastructure, bureaucracy, socio-political system, carbon footprint management, human rights and so on (Gelfand et al, 2007). Australia being on a distinct and better ground on these issues can possibly compete in the world stage by forming a consortium with these countries while benefiting in its own domestic economy at the same time.

People need a way to reduce the complexity of the surroundings into a manageable number of categories and to understand how these categories relate to each other and that is why enterprise modelling is so important for effective enterprise re-structuring (McGregor, 1987). When given an integrating framework using common enterprise modelling language, people are able to simplify and understand the complexity around them. It enables them to think clearly about difficult issues, to build shared views and maps with others and work collaboratively. It enables them to communicate about an otherwise complex business and promotes a sense of predictability in an otherwise unpredictable environment.

Enterprise Modelling is a rich but relatively new research domain that has been mostly dominated by researchers from software engineering, computer science and ICT (information communication and technology) disciplines over the last three decades. It has sprung from its very deep root in computer integrated manufacturing (CIM), information systems and automation. The body of knowledge that has grown over the years by the commendable work of the pioneers and predecessors appear to have been inadvertently biased by their own disciplines and a holistic approach is lacking. This is possibly due to its isolation from other branches of science and engineering such as management science.

According to Schekkerman (2008), US topped the list of top 20 countries in the world in the use of enterprise modelling activities with 45.27% using reference architectures compared to Australia 4.66%, China 1.07% and India 2.60%. One would then possibly argue that the reported apathy from industries in most countries of the world to embrace enterprise modelling as an effective tool for all round enterprise-wide improvement and efficiency could, therefore, be a reflection of this isolation and is due to lack of awareness amongst line managers and practitioners about its application and potential benefits.

In recent times, complexity of businesses has increased - so has competition and customer demand. This is possibly due to a number of socio-economic, political, technological factors arising out of issues such as globalisation, recession economy and climate change and so on (Devaraj et al, 2007). As a result, a paradigm shift in thinking is already emerging to explore new enterprise architectures and modelling techniques to run businesses of tomorrow (Martinsons, 2008).

The literature review suggests that previous researchers have not attempted to develop country specific enterprise models and compare their characteristics as such. Industry case studies conducted are very few and almost lacking. Due to the dominance of the enterprise modelling research domain mostly by IT academics and industry practitioners a holistic model based on management science is practically non-existent thus making the subject difficult for managers and industry practitioners from disciplines other than IT. It is also observed that simple, step by step practical approach to enterprise modelling is totally missing. Based on these observations the literature review was undertaken in detail and the research gaps were indentified into a number of distinct areas that have subsequently been grouped into sub-sections as hereunder.

The following subsections are classified on different headings to group literature review in different clusters that could consolidate on specific issues for development of various sub-models.

- Enterprise Modelling

- Enterprise Architecture

- Information Architecture and Enterprise Architecture

- Enterprise Reference Architecture People-Oriented Architecture

- Micro Level Architecture

All these subsections are related to enterprise Modelling and Architecture that leads to the development of modeling approach for Chapter 3 and 4.

However the road map for the other following sub-sections and corresponding leading to subsequent Chapter are describe below.

- Kaizen Lean Sigma leads to Chapter 5

- Manufuture Vision and Globalisation lead to Chapter 6

- Value Sphere Disaggregation leads to Chapter 7

All the above sub-sections together leads to Chapter 8 followed by discussion in Chapter 9 and finally conclusion is discussed in the last Chapter 10.

## **2.2 Enterprise Modelling**

An enterprise model is a representation of a perception of an enterprise. It can be made of several sub-models, including (but not limited) to process models, data models, resource

models, and organisational models. It can be something very sophisticated and elaborate, or it might be represented with a simple sketch of the plant layout.

The enterprise model can be viewed from different angles. In practice, for the sake of clarity it is not possible to show all aspects of the enterprise in one single model, since the model would then become very complex and hard to work with. Usually the enterprise model contains those aspects that are crucial for solving specific problems. In a manufacturing context, important aspects to include in the model are:

- Processes: Manufacturing and business processes (administrative, management, finance, etc)
- Products: Product information including all technical data and the manufacturing processes that are necessary to produce the product.
- Resources: People, physical machines, devices, and applications (software packages)
- Raw Materials: Natural, modified, or semi-processed basic substance used as an input to a production process for subsequent modification or transformation into a finished good.
- Information: Anything that can be represented by data
- Organisation: Organisational charts, goals and objectives and so on
- Environment: Enterprise environment (both internal and external), business constraints, legal issues, government regulations and other enterprise/business partners, etc.

The difference between different enterprise models might lay in the purpose of the model, the content of the model or the level of abstraction. Any kind of enterprise model serves a specific purpose, of which there are many but fundamentally any enterprise model aims to make people understand, communicate, develop, and elaborate solutions to existing business problems.

According to Holt (2009), a model is any construct which shares some important properties with a real or contemplated system that is being modelled. He views all enterprises as a collaborative effort of many individuals that are in a constant flux of change. He also



emphasizes the need for communication between people with different disciplinary background (cross-functional teams). Following this system approach, Enterprises in the 21<sup>st</sup> century demands constant change in order to adapt to the dynamic, global business environment (Wagter, 2005).

In its simplest form there are two aspects to the model. The first constitutes the components which one has available to work with and the second constitutes the structure in place by which components available can be manipulated. In another perspective, the components are held together to form a structure which defines the scope of influence.

A model reflects all the traditional areas of economics, finance, marketing, human resource management, politics, personal interactions, and belief models etc., which define people, their interactions and how they behave. It does not redefine these, but it does put them into a holistic perspective which is unbiased by any one perspective or approach.

Enterprise modelling as a concept, tool and the way to improve enterprise performance through integration and enterprise engineering efforts is only 20 years old. The model provides a means for the exploration, development, testing, implementation, and evaluation of that which it represents (Szewczak and Snodgrass, 2002). This provides a framework for ensuring that the enterprise will achieve its goals and objectives, starting from the time when the enterprise is being created, during its lifespan, or when it is undergoing some type of change.

The enterprise model is based on defining and evaluating a "sphere of influence", and how that "sphere" evolves. It is dynamic in nature, because over time, the sphere of influence changes based on choices made, actions taken, and a change in the environment it operates within. Every individual or organization has some sphere of influence and over time they attempt to extend their sphere of influence to the maximum extent possible. As this sphere is extended several effects may be observed, including competition, mutual cooperation, or specialised niche development. In case of individuals these effects are dependent on personality type and their environment.

The enterprise is alive in a very tangible way, but it is hard to visualize how it came to be, how it has grown and how it will continue to thrive (Lankhorst, 2005).

## **2.3 Enterprise Architecture**

Fundamentally an organization is a socio-economic entity. It is a composite of inanimate and animate objects. It is vibrant and living only because of human presence in its heart and soul (Grigoriu, 2006). According to Khoury and Simoff (2004), what is needed from enterprise architecture is a method that is effective in developing a single and coherent model of an enterprise, and allowing us to guide the future development of an enterprise without the creation of arbitrary internal boundaries.

Watson et al (1997) argue that an enterprise architecture methodology must be designed to produce specified, predictable results. It must specify not only “What to do” but most importantly, “How to do it” and “Why”. Moreover, it must be based on a set of concepts and principles that theoretically, logically and empirically establish a basis for producing an aligned, integrated, responsive, flexible enterprise architecture that in fact can be used to engineer, manufacture and implement an enterprise. A methodology which does not comply with these criteria is a waste of time and money (Moriarty, 1996).

Every enterprise has its enterprise architecture. However, typically it is not explicit, not formalised, relatively unknown, and not managed. The problem is that enterprise architecture efforts have been very sporadic. Enterprise architecture, as it is practiced today by most people, is still a random, un-disciplined, and trial-and-error activity (Goranson, 2003).

An enterprise may be perceived to be inter-connected through a digital nervous system that ensures a well integrated flow of right information to the right part of the organization in right time. When the digital nervous system of an enterprise ceases to function properly or dies, the enterprise still remains alive but may be in a heavily impaired state or condition (Inmon, 2001). For an in-depth knowledge of the enterprise one would therefore need to look at its various sub-systems in terms of their inter-relations and functions as an integrated whole.

Most surprisingly, many business and manufacturing managers have never even heard of enterprise architectures (EA) because most of the literature in the field focuses on IT (Information Technology) only (Gunasekaran, 2003). Real EA is not about IT at all. Although IT is significant, it is only one small part. EA is about the structure of the whole of enterprise. It is the integration of everything the enterprise is and it does (Cummins, 2002). The term architecture is a generic description. It refers to a much larger scale of operations. It is the scale of the whole rather than a single sub-system. In something of this size there are no simple states of “as-is” versus “to-be” because this world is dynamic not static (Liu et al, 2008). What is therefore required is something simple that will allow a modeller to start small yet keep a consistent structure that would allow expansion of scope upward to the whole of enterprise and its environment - a system for EA. The study of IT architecture has been around for over thirty years. The field has been well researched but its relationship with EA still requires further exploration (Chorafas, 2001).

Every enterprise is composed of a series of lifecycles – development lifecycles, integration lifecycles, operational lifecycles and these are all contained within the larger organism of the lifespan of the enterprise itself (Hysom, 2001). Where is the map, i.e. the key to how and why it developed the way it did? EA is almost always attempted across painful fits and spurts – rarely if ever does it become a permanent part of the larger lifecycles that spawned it. When the EA efforts are tossed aside, knowledge is lost, opportunities for continuity missed and the roadmap vanishes beneath the shifting sands. Once one takes the philosophical leap as to what the true nature of EA ought to encompass a number of other realisations start to become apparent, including:

- Narrowly defined or highly specialized EA frameworks that are not flexible enough to encompass an enterprise, a lifecycle or combinations thereof (Iyer et al, 2005)
- The language of architecture must at all times be accessible to all participants in the enterprise and once the visualisations, notations, frameworks or terminology become the province of ‘architecture experts,’ the value of the architecture has been lost and the EA will gradually or rapidly wither away (Martinez et al, 2001).

- According to Mezgar et al (2000) EA is also a communication medium, the basis for all other collaboration, the reference point for conversation to begin and also the parameters for discussion.
- Neaga and Harding (2005) argue that the EA must have the ability to be subdivided without losing its 'DNA' integrity and must encompass the enterprise lifespan allowing for unlimited lifecycles within - the only way to build true organizational traceability.

EA is an imperative to success for all organizations that must operate in today's fast changing complex business environment (both internal and external) to be successful. It also requires to be integrated with its offerings, capital planning with interwoven involvement of people the 'heart and soul' and its architecture effectively (Zaidat et al, 2005). Unfortunately, these EAs invariably provide tombs of information that are difficult to navigate and use in any effective fashion. A recent field study conducted in Australia, China and India also suggests that most EA programs to-date has not fully lived up to expectations (Gu, 2006).

An enterprise architecture (EA) is a co-operative effort of designers, analysts and managers and uses enterprise models in the process. Bernard (2005) defines EA as a management program and a documentation method that is combined to perform on an actionable and coordinated views comprising of the enterprise strategy, business processes, resource utilisation and information flow. Hence, an EA is analogous to a homeowner discussing high level plans for a house with an architect. After the plans are made, the architect or the builder (designer) can make tactical changes later on to meet other requirements, but the overall framework will stay the same (Cook, 1996). An EA is therefore a high level planning guide for building the infrastructure out and therefore needs to be flexible enough to accept minor changes down the road (Chorafas, 2004).

Enterprise Architecture (EA) is the science of designing information-based structures. It describes the theory, principles, guidelines, standards, conventions and factors for managing information-based structures within an enterprise. It creates abstractions of an enterprise in the form of drawings, charts, plans, documents, models, designs, blueprints and templates. Collectively these are known as corporate knowledge (Boughzala, 2006). The focus of EA

is on how to make an organization more effective. EA techniques are used to leverage information-intensive programs and initiatives.

Corporate knowledge is used to understand and manage the inherent complexity in an enterprise by creating a holistic picture or map of its principal structural components and their relationship to one another. EA is a broad discipline that embraces a large number of sub-architectures, such as data architecture, security architecture, network architecture and process architecture (Doroshenko, 1999). It is a meta-discipline that embraces ideas from many other disciplines. The focus of EA is on how to make an organization more effective. Many practitioners of IA, however, preach that their approach is the only valid one. In fact, many information architects don't even acknowledge that there are other ways of doing things.

According to Jones and Mingay (1999) the common word “architecture” in this context is merely a set of shared definitions and constraints that are expected to effect a time, cost or risk reduction in future application development or operations.

Putnik and Cunha (2005) argue that a limitation of architecture is its reliance on the predictability of both the business needs of the future as well as the upcoming technology needs. If the exact business requirements were known, then all that is needed is a design, not architecture. However, the design describes these requirements at the time of creating a new enterprise (e.g. a large scale project) or modifying an existing enterprise (e.g. continuous improvement), using tools such as functional constructs and data models.

The enterprise designer will need the architecture to capture these requirements at a higher level (McKeen and Smith, 2003). Therefore the life span of an enterprise design has a direct bearing on the future business environment. Uncertain and volatile business environment will inflict shorter life span to the enterprise (Sauer and Willcocks, 2002). What that means is constant revision of the enterprise design in tune with the current requirement for every 2-3 years and of course along with associated costs. Once the enterprise is designed, a strategy is required to define not only “what” is to be accomplished, but also “how” it is going to be accomplished (Boar, 1993).

## 2.4 Information Architecture and Enterprise Architecture

EA is, however, known by a variety of other names such as Information Architecture, Application Architecture, Business System Architecture, Enterprise Wide Technical Architecture; the basic process is the same – to develop a high level plan of how IT will meet future business problems (Rolstadas, 1995; Giachetti, 2004). It is therefore necessary that the above mentioned “subsets” of IT-planning are briefly defined:

- *Information Architecture* – a part of Enterprise Architecture, that focuses more on the application and data aspects of an IT system. Often includes the Application Architecture (as below) and the corporate data model.
- *Application Architecture* – highlights the data flows between applications in an integrated information system (Hunter and Tan, 2005)
- *Business System Architecture* – a mix of the strategic plans for both IT and business resources. It is normally in pictorial form and used for high-level planning (Kaomea and Page, 1997)
- *Enterprise Wide Technical Architecture* – Another name for Enterprise Architecture, that stresses the technical as well as the infrastructure components of EA (Medawar, 1995)

The concept of an information architecture evolved from IBM's pioneering efforts in this area, resulting in the development of the Business Systems Planning Methodology (BSP). The concept was further developed by Zachman and Sowa (1992). The Zachman Framework facilitates the establishment of the underlying infrastructure for managing the information asset and is analogous to city / town planning - which allows the city to build on and thrive in a managed fashion.

An Information Architecture establishes decision making principles and standards for the use of information as a business resource. It also coordinates, integrates and harmonises technology practices and planning throughout the Company. From a management perspective, it can also be viewed as a process to identify issues and conflicts in the area of information management (Ruh, 2005).

Today IT is so much embedded and deep rooted into any business that it is more of a business asset that needs to be controlled, monitored, and managed like any other asset such as buildings, factories, or plant and machinery and EA allows a company to treat all of its IT assets as a portfolio rather than individual items (Halpin and Morgan, 2008).

The term strategy, in the context of Enterprise Architecture (EA) development can be confusing to cross-functional teams. Both the terms strategy and architecture are relatively analogous (Krogstie et al, 2005). Normally architecture is thought more as a static picture that you draw on a paper whereas strategy is more like putting the architecture into motion and therefore dynamic in nature. Most large companies are too busy fighting fires, solving short term tactical solutions and not developing long-term strategic plans. Just as planning your business strategy takes a different mindset, so does developing an EA (Strong et al, 1997). People in an organisation are more focused on the project at hand rather than looking at their environment they operate within - from an enterprise standpoint. Once the architecture is defined, then individual business units merely have to see where they “plug-in” to it to get their work done (Reich and Nelson, 2003). For example, if the architecture plans says to go towards a unified ERP solution, such as SAP, and a business unit wants a payroll system, maybe looking at SAP is a good start. Or if UNIX systems are the “standard”, then that part of the design is already done.

Today’s ideal information systems are flexible and invisible information infrastructures that constantly adapt themselves to the actual resources, products and business decision processes of the enterprise. They are no longer a constraint to developing a differentiating, winning strategy (Engwall et al 2005). Attaining the ideal information system implies reaching the highest level of maturity in development and maintenance, minimising the effort needed to implement and support continuously improving manufacturing and business processes and benefit from the technology as it is available, when and where appropriate (Dolk and Kottermann, 1993).

An Information Architecture (IA) needs to be developed giving due consideration to:

- values of the organization, business principles and degree of decentralization

- technology risk assessment of information technology evolution and direction of the organization

The three distinct yet inter-related parts of an IA-managed organizational framework are (Luftman, 2000):

- Data Architecture - The major kinds of data (and the relationships between them) with common definitions, needed to support the business
- Systems Architecture - The major systems (applications) and their inter-relationships that manage the data and support the execution of business functions (i.e. Plan and schedule work)
- Technology Architecture - The technology environment needed to enable and support applications that manage the business data

## **2.5 Enterprise Reference Architecture**

An Enterprise Reference Architecture (ERA) has gone through extensive research and is a framework by itself that stimulates the architecting process encompassing all activities during the lifespan of the enterprise. They are usually accompanied by a methodology (or methodologies) that detail these activities as well as propose modeling tools and modeling languages to be used by the architecting process. Reference Architecture (RA) is analogous to the anatomy of the life-cycle of the enterprise. It describes the logical structure of activities with interfaces between functions through information or data exchange (Santos et al, 2000). Existing enterprise modelling methodologies take static views of the enterprise and do not naturally lead to a path of improvement during enterprise model transformation (Vella et al, 2009). What is missing from EA frameworks is a focus on an integrated view of the key components of the enterprise and a way to align them with customer and business needs. This calls for a new mindset across the organization and willingness of the people to embrace change which is easier said than done. According to Mo et al (2005) any fundamental change upsets people, creates apathy that brews resistance. They had observed similar inherent resistance to change while studying virtual enterprises such as the RELINK project.



An Enterprise Architecture Framework (EAF) describes how an Enterprise Architecture (EA), consisting of information, people, applications, business processes, technology and infrastructure, can be modelled in its entirety (Mylopoulos, 2008). EAF is simply a means of structuring and classifying architecture models and views. EA is implemented through the use of EAF. Several different frameworks exist, for which some are considered general purpose while others are highly specialised (Wenzel et al, 2005).

Since the 1990's, enterprise architectures (EA) provide a general representation of the relationships among different enterprise views at various abstraction levels in the enterprise's life cycle (Bernus et al, 2003). Today, four enterprise reference architectures are internationally recognized: Computer Integrated Manufacturing Open Systems Architecture (CIMOSA), Purdue Enterprise Reference Architecture and Methodology (PERA), GRAI Integrated Methodology (GIM), and Generalized Enterprise Reference Architecture and Methodology (GERAM).

CIMOSA focuses on building an information system for manufacturing and government agencies (Kosanke et al, 1999). CIMOSA hypothesises a generic reference architecture that can be instantiated to partial architectures for specific industries. The partial architectures can then be further instantiated for individual companies. It is a process-oriented modelling approach containing four views: Function, Information, Resource, and Organization.

GIM focuses on the influence horizon of the decision making system in an enterprise (Chen et al, 1997). GIM originates from GRAI, which has a primary goal to help manufacturing system designer to build production management systems (Doumeingts, 1985). It is a structured approach visualizing the whole life cycle of a system from two points of view: user oriented and technical. However, the use of GIM in enterprise modelling needs significant effort to develop implementation details.

PERA has a focus on life cycle processes in the development of an integrated enterprise (Williams, 1994). In its fully developed form, PERA provides a detailed and pragmatic methodology covering the whole life cycle of an industrial project from inception, through to operation and system disposal. It is particularly suitable for large scale one-off project development that incorporates complex engineering design and services activities.

Pantakar (1995) observed that application of the three (CIMOSA, GIM and PERA) architectures have been focused mainly on manufacturing enterprises they are yet to be proved in the integration of different size companies involved in the lifecycle of a product or service. Therefore all these architectures can be improved as they have not completely generated the necessary methodologies, modelling techniques and adequate execution tools for the different kinds of enterprises.

Enterprise integration is an outcome of engineering enterprise using enterprise models and is very important in industrial world nowadays because of the growing need to improve existing industrial systems and to organise such complex systems faster, better, and in a more systematic way (Ortiz et al, 1999). The IFAC/IFIP Task Force (1999) compared the characteristics of all major contemporary architectures and developed the Generalised Enterprise Reference Architecture and Methodology (GERAM), which was later adopted as part of ISO 15704. The various requirements and components, which all reference architectures have to fulfill in order to be considered complete, are synthesized in GERAM's generalized mapping mechanism. Hence GERAM is not 'another' enterprise reference architecture, but is meant to organise existing enterprise integration knowledge (Vernadat, 2001). GERAM does not define its own process but rather provides a framework to coordinate an international standard for enterprise architecture. It defines a tool box of concepts for designing and maintaining enterprises during their entire lifecycle. GERAM is therefore about those methods, models and tools which are needed to build integrated enterprises. It does not impose any particular set of tools or methods, but sets the standard for the collection of tools and methods. Williams and Li (1995), however, commented that due to political factors, it has been impossible for the members of IFIP-IFAC Task Force to create an architecture that could be considered by everybody as the best.

The Zachman framework is probably the most popular approach to enterprise modelling in business environments. It provides a matrix that segments the enterprise into a variety of different views based on the different roles an actor can take e.g. owner, designer, builder. Since each view is modelled independently, each segment interface presents a discontinuity. Thus, the issue of the Zachman framework is that it divides the organisation into distinct segments which defeats its goal to integrate the organisation. While the framework provides

an observation of some natural rules for segmenting an enterprise into understandable parts, there is little analysis of the laws and principles that govern these natural rules. As a result, the Zachman framework remains primarily as taxonomy with issues guiding the development of enterprise information systems.

## **2.6 People-Oriented Enterprise Architectures**

Business runs on relationships: company to employee, brand to customer and partner to partner. In the fast moving materialistic world, human emotions are frayed throughout a company's value chain. This may create a new business opportunity for people centric companies (Banerjee et al, 2003; Das and Teng, 2001). The key to building and keeping relationships is emotional talents such as confidence, friendliness, empathy and authenticity. Relationships of business with its talent, partners and customers are the most valuable assets.

Dyer and Chu (2003) argue that trust is unique as a governance mechanism because it not only minimises transaction costs, but also has a mutually causal relationship with information sharing, which also creates value in the exchange relationship. Their findings provide empirical evidence that trustworthiness lowers transaction costs.

Twenty-first century organisations will require designs that enable them to cope with hyper competition, radical changes in technology, and new workforce values. They are striving to become less bureaucratic, and simultaneously, more cooperative, lateral, and team based. Lateral organisations utilise structures that range from simple direct contact relationships and liaison roles, through group-based forms utilising teams and task forces, to formal lateral structures, such as project management and matrix structures. Galbraith (1973) argued that lateral organisation represents one of several alternative organisation designs that managers can choose from for dealing with the information processing demands imposed by high levels of task uncertainty.

Irani et al (2002) describes how the formation of self-directed work teams (SDWTs) is used as a strategy for motivating a diverse group of people with different attitudes, skills and personalities, to work together towards common business goals. Particularly, emphasis is

placed on the role of the team facilitator within dynamic teams, and the necessary attributes of such a facilitator are identified. This identification also assists in providing an understanding of how a facilitator can assist in curtailing conflict.

In the transformation of business, people become the new enterprise platform. A people-centric approach is absolutely critical to understanding and building the processes and systems that facilitate the social business transformation (Takeishi, 2001). It defines current social and business progression past the industrial society's focus on business, technology and process. People oriented EAs do not rely solely on business or technology or process, but instead they become supporting structures that facilitate new ways of collaborating and interacting with customers, suppliers, partners and employees (Zhao et al, 2008). The idea also has to permeate system and process design. From a system perspective the customer service needs something to bring interaction with systems, information and people together. Working with customers, internal and external business partners, suppliers, logistics providers, at the core they're all people-centric issues (Vecchi and Brennan, 2009).

Current systems do an adequate job of facilitating work as a business process. The problem, however, arises when the work doesn't fit the process. People today often spend much more time on problems that fall outside of the business process or exception processing. Exception processing often involves working outside of systems and gathering temporary teams to work through the issues (Wacker and Sheu, 2006). These ad hoc work requirements are a necessary part of the business but can take an inordinate amount of the resources. Since they rely on people to resolve the exceptions, most of these works are regarded as inefficiencies that fall outside the enterprise systems and processes. The preference is to eliminate these activities and hence are not studied and managed. However, they are integral parts of modern enterprises. Therefore what is needed is collaboration systems that are people-centric and capable of effectively dealing with the ad hoc nature of information-based work (Browning, 2009). For example project management is about executing against a plan, or in other words about people working together to accomplish some end goal which by its nature is people-centric. According to Combs and Ketchen (1999) many enterprise tasks today have moved to a more people-centric method and the systems have not caught up.

Cost of skills, resources and time are absolutely critical for a service oriented enterprise that bills customers against man-hours (Sridharan and Berry, 1990). The bottom-line for sustainability and survival of any business is to have a cash flow through transaction of goods and services. Any job or project can be viewed as an outcome of a number of well coordinated and synchronized tasks that need to be accomplished against a given time-frame (schedule). Any task and the time available for its completion determine the levels and variety of skills (people) and resources (tangible and intangible) that are required (Detert et al, 2000). Skills, resources and time become the determinant factors for the assessment of cost for any task towards production of goods and services.

## **2.7 Micro Level Enterprise Architectures**

Information transparency enables partnering and trust. In the old economy, suppliers were treated as external to the firm and relationships were combative (Gefen and Carmel, 2008). Corporate bureaucrats told suppliers to reduce prices or lose their business. Information flow at lightning speed qualifies the tendency of any entity to adopt a molecular structure. Small, flexible, adaptable, expert units can function independently or gather temporarily depending on expected benefits (Kotabe et al, 2003).

McDavid (2005) views enterprises as human social system. He raises various architectural view points to augment enterprise as a social system that limits the successful application of technological prosthesis or design of the structure and relationships. He argues that the micro-architecture of business is something like the molecular structure of the fundamental 'stuff' with apparent commonality and simplicity. The micro-architecture of all business organisations is composed of a structure of conversations, commitments, contracts, and transactions.

An atom is the smallest particle in matter that still maintains its chemical identity. A single person is like an atom in the cyberspace ready to be attracted by an opportunity for further interactions (Mansar and Reijers, 2007). Human atoms can enter any value chain or network of networks under suitable conditions of market demand, technology and customer and so on. Under dynamic conditions human atoms combine, compete, separate, and move in and out of a network.

Miniaturisation to micro-architectural level means freedom, variety, less bureaucracy, opportunities for skill enhancement and lifelong learning, and maybe even more income (Kathuria and Partovi, 1999). Highly competent individuals will gain pride from their premium market valuations. But this scenario has its downsides. Job security, as most people understand it, declines. Companies terminate contracts with individuals for infringements that would not warrant firing in the traditional employment model (Kulp et al, 2004).

Tapscott (1997) proposed the concept of molecular economy based on molecular organisation using the properties of molecules. He also argued that the knowledge worker was a “human molecule” that functioned as a business unit of one. His focus was on disaggregation of large corporations but did not elaborate in relation to manufacturing industry and was short of explaining how the molecular properties drove the operation aspects of Molecular Organisations. Smyre (2009) modelled molecular corporations being built around an atomic concept with the vision, brand portfolio and administrative function of the corporation at the core. Smyre’s model was based on loosely-bonded atoms of organizations that provided business functions that would eventually be outsourced. The model suffered from the lack of further interpretation of properties of atoms and molecules for explaining the structural and functional information about micro-level enterprises. Kirkpatrick (2001) discusses the fallacy of large corporations and suggested “killing the corporations” as a means of solving the economic problems in the 21<sup>st</sup> century. In this argument, the concept of molecular organisation is used to define the boundaries of operational units as separable elements in the large corporations so that these corporations can be broken down effectively. The argument was useful to lay the foundation of a new concept in enterprise architecture but did not have the basis of how this could be done or how the broken down units could operate. According to Shipley (2003), the centre of the organisation is a strong atom - the corporate core. That core owns the brand portfolio, the vision, and the administrative function of the corporation which is the atomic essence of the organisation. Coupled to this strong atom are other atoms either strongly or loosely-bonded. These atoms provide all the other business functions of the corporation. Her work lacks references to the previous research work and does not include the structure and properties for MO’s.

Despite commendable efforts by various researchers on issues related to disaggregated molecular organisations, a scientific analogy of molecular structure, their properties and reactions as applicable to such MO's have not been addressed. Further explanations in regard to how these MO's would function and interact in real business environment are also lacking in the research attempts. Cook (2003) proposed an 'organizational diagnostic molecular model' for innovation where the mission, values and culture constitutes the nucleus. According to his assumption, organisational structures were analogous to the quantum physics model of an atom and are not supported by any reference or scientific analogy at all.

Green (2002) observed that the molecular unit of business is neither about the corporation nor the business. It is about the individuals. However, Green's work was not supported by other researchers. Comparing humans with both atoms and molecules at the same time does not seem logical in the analogy drawn by researchers. The problem is, therefore, to understand and explain the dynamics of molecular interactions in the context of MO's (Bhasin, 2006). How to draw an analogy between chemical science and management science? Why are considerations of the properties of atoms, molecules and their interaction in a chemical reaction through bonding, are so critical in the analogy? What are the artifacts for these MO's in case one wishes to model such tiny, loosely-coupled and disaggregated MO's?

Researchers of MO's have failed to address the fundamental issues of structure, properties and interactions of the MO's while drawing analogies from the concept of atoms, molecules and their interactions in forming chemical bonds. Relevant research work falls short in providing adequate scientific explanation to the analogy drawn upon established concepts of chemical science. The basic question is how such MO's would possibly function in view of the increasing trend towards disintegration and disaggregation. Can the established theories of atomic and molecular structure and their role in chemical reaction be applied to explain the behavioural properties for MO's? None of these researchers have attempted to develop a model for MO's with appropriate artifacts to explain the structure, properties and interactions of MO's. Existing literature review also does not suggest any framework for the MO's explaining how it would work and why. A pathway from concepts of atoms,

molecules, elements and compounds to MO's is totally absent. Despite the concept of atoms and molecules being two centuries old, the researchers have not attempted to apply the analogy into the operational aspects of MO's.

## **2.8 Kaizen-Lean Six Sigma**

Over the decades many improvement tools have been tried out in the factories and businesses with spectacular success – Total Quality Management (TQM), Kaizen Blitz (KB), Lean Six Sigma (LSS), Toyota Production System (TPS) and of late the IT enabled tools such as Enterprise Resource Planning (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM), Manufacturing Execution System (MES), Computer Integrated Manufacturing (CIM) and so on and the list is never-ending (Bendeloy and Schoenherr, 2005; Pibernik and Sucky, 2006). On top of these ever increasing list software vendors, consultants and certified champions such as Six Sigma Black Belts, Green Belts are regularly knocking company boardrooms to sell their individual and/or company owned packages or expertise (Gordon, 2003). As a result decision makers at the top end of the hierarchy, who may not necessarily have a clue to these new tools and jargons, are suddenly deciding to buy-in some of these fancied and trendy improvement packages and then dumping them on to the shop floor dreaming for immediate return on investment (ROI) that were likely to please the shareholders with sizable dividends (Gibson, 1999). Supervisors and operators on the shop floor are sometimes flabbergasted with the abrupt and fancied decisions by the corporate that are erratic and incoherent (Fok et al, 2001).

A number of established methodologies are currently used in manufacturing plants to achieve five key strategic objectives cost, flexibility, speed, dependability and quality by improving overall performance (Flynn et al, 1994). Most popular established methodologies among manufacturing plants are, however, Lean Manufacturing, Total Quality Management (TQM) and a hybrid approach of Lean and Six Sigma (Shah and Ward, 2003). The Six Sigma philosophy maintains that reducing 'variation' will help solve process and business problems (Pojasek, 2003). According to Tennant (2001), the component parts of a Six Sigma quality initiative include: TQM, which provides tools and techniques to bring about cultural change and process improvement within an organisation.



Sharma (2003) mentions that there are many advantages of using strategic Six Sigma principles in tandem with lean enterprise techniques, which can lead to quick process improvements. It is sometimes difficult for a company to translate or leverage such improvements enterprise wide because no infrastructure exists to do so quickly and efficiently. By introducing Six Sigma principles into the improvement mix, it becomes possible to put in place a business process framework which leverages benefits in one process to other processes in an organisation (Shah and Ward, 2007). Among all the methodologies, no one method can be concluded to be the best. A methodology will only be good as those guiding and executing it. That is why people are so important in any six sigma improvement.

Dale (1999) says that the development of people and their involvement in improvement activities, both individually and through teamwork, is a key feature in a company's approach to Lean Six Sigma (LSS). A key aspect of this is making full use of the skills and knowledge of all the employees to the benefit of the individuals and the organisation.

The central concept behind Toyota Production System is to reduce costs by eliminating wastes. The 7 types of wastes that have been identified by Ohno (1988) include overproduction, waiting, transport, processing, inventory, motion and defects. Toyota aims to continuously reduce costs by putting into effect improvements to eliminate each of these wastes. An enterprise which is aware of this simple but crucial aspect of combining technical improvement initiatives with people will accelerate implementing LSS or any other improvement method. The performance of a business is determined by the complex interactions of people, materials, equipment, and resources in the context of the improvement program that manages these interactions (Ward and Zhou, 2006). While both Six Sigma and lean management represent the state-of-the art change management theory, each system gives priority to certain facets of organizational performance. Therefore, in a highly competitive environment, diminishing returns may result when these programs are implemented in isolation (Ahire and Dreyfus, 2000).

A well-structured and executed business process with Continuous Improvement (CI) initiative requires an integrated approach to derive benefits from all the tools (e.g., Kaizen, TPS, Lean or Six Sigma) at the same time avoiding duplication of efforts and resources

since selective deployment for the highest impact opportunities creates a rapid, winning strategy (Challis et al, 2005). This further justifies the critical importance of strategy in any CI initiative. Six Sigma and Lean are both management philosophies and a set of tools. When comparing, contrasting and integrating, one must look at the philosophy and tools separately. In defining Six Sigma and Lean tools, “process” is the key (Elenkov and Manev, 2005). With Six Sigma, the tools focus on using statistical analysis to help reduce variation. Lean is a more of a “macro” approach to deal with improving lead times, reducing inventory and eliminating waste. Both sets of tools are vital for enterprise wide improvement. Despite their popularity systematic studies on the modelling aspects of integrated CI-tools is lacking in the literature (Hayes et al, 2004).

The word “kaizen” is used in the business world to depict a team working on a quick continuous improvement project. The word is actually Japanese for “incremental improvement”. According to Chinvigai et al (2007), it is important that everybody’s participation is required everywhere in the organisation. There are also non-traditional ways to utilise a kaizen event. For example, Six Sigma is a more data-driven approach to continuous improvement, often utilizing advanced statistical concepts and design of experiments (DOE). However, during a six sigma project, there could be a very good reason to utilise a kaizen event (Joshi et al, 2003). This justifies a need to integrate Kaizen with Lean Six Sigma so that duplication of efforts are avoided and at the same time maximum benefit is derived by the organisation without further repercussions on cost (Keller et al 2005). Modelling of business processes has, however, become a requirement for implementers of ISO 9000:2000 quality management recommendations.

According to Brown et al (2008) an enterprise needs to improve, adapt, transform and reengineer its processes to meet constantly changing output deliverables and customer expectations within an increasingly competitive global environment. Enterprise modelling alone has not been successful in inflicting such required improvements on a continuous basis. Due to the fast changing business environment, the new model of the enterprise is a moving target. It takes a long time to progress from the current model to the newly designed enterprise architecture. When the changes are done, half way through the transition, the enterprise designer is already under pressure to make further changes to the design under the new environment.

An organisation would therefore require a plan or method that would help to cope with such frequent and dynamic changes. People need a way to reduce the complexity of the surroundings into a manageable number of categories and to understand how these categories relate to each other and that is why the need for a new method in enterprise modelling is so important today (Farhoomand and Drury, 2002). When given an integrating framework using common sense language, people are able to simplify and understand the complexity around them (Pfeifer et al, 2004).

The enterprise architecture (EA) design approach focuses on designing the enterprise at different anticipated development stages using established enterprise design guiding principles (Uppington and Bernus, 2003). The success of the new (future) enterprise depends on the “correctness” of the enterprise vision and its well managed implementation. The continuous process improvement (CPI) is therefore always risky and is generally non-responsive to external environment. There is no systematic study on how an enterprise should embrace CI to achieve a less risky but progressive path (Khanna et al, 2010). A new approach is required to assist enterprises not only to define their enterprise models, but also to re-engineer their processes and structures in a predictable way (Prasad and Tata, 2009).

A business can be viewed as a series of interacting processes. Thus, an enterprise can be viewed as a collection of integrated processes interweaved with the four views strategy, business processes, organisational structures, and information systems of the enterprise. Enterprises need to interweave the deliberate with the emergent. A review of current research and industry literature suggests large gaps exist in terms of strategies, processes, structures, and information systems that intrinsically, fundamentally, and seamlessly interweave the deliberate and emergent aspects to support adaptive enterprises (Peko and Sundaram, 2010). According to Gordijn et al (2000), business process models are, however, not the same as business models. Business models describe “what” value is generated and offered whereas business process models describe “how” this is done. Thus input-outputs are more relevant to business process model. A business process model justifies the need to show resources as one of the inputs and product / services as output. A business process transforms inputs (both tangible and intangible) into outputs (tangible and intangible).

The overall objective of enterprise improvement is to redefine its processes and reduce their inadequacies with appropriate tools to ensure that the process requirements are satisfied and at the same time relevant operational targets such as cost, delivery, productivity, and so on are met (McGinnis, 2007).

According to Potts and Doucet (2009), EA is a continuous improvement agent, not as simple as “AS IS”, “TO BE” and the way to get there. The EA provides a common language for people to design a continuous improvement project. EA is about people. People always focus on projects but the steady state should be the focus. If the organisation gets a coherent view then the management and the employees eventually do better decisions. People are the key in relation to rapid change (and a barrier).

There are no systematic modelling studies for Continuous Improvement involving the operation phase of an enterprise lifecycle available in the literature. There is also a need for the unique role that people play, in any operational model in any CI initiatives, to be reflected in the Enterprise Model of an organisation.

## **2.9 Manufuture Vision**

To apply the latest strategy, companies need to embrace significant paradigm shift as a transition from competing on cost to competing on added value. The new paradigm requires high performances, customisation, new business models, new human capital and a service dimension in manufacturing. New thinking such as “Manufuture” represents powerful vision linking human and societal needs (Manufuture Forum, 2006). Manufuture Vision is intended as a tool to guide the future development of manufacturing in Europe, including a strategic research agenda to shape manufacturing activities under the framework programs and other initiatives such as Eureka, and possibly leading to the creation of a 'MANUFUTURE platform', along similar lines to other European Technology Platforms (ETPs).

The high level group predicts that the sector will begin to change in a number of ways. First, they will have the desired effect of moving the manufacturing sector from a resource-based to a knowledge-based model. The scientific engineering knowledge content of manufactured

products was estimated to be around 5 per cent in 1945 and has grown to some 16 per cent now. The target for 2020 should be at least 20 per cent states the report. The manufacturing industry will move from mono-disciplinary to a system based on multi-competence and multi-disciplinary innovation, and production scales will move from the macro to the micro and nano-scale. Further into the future, the group foresees a fundamental switch in the nature of production: 'Over a longer timescale of, perhaps, 20 to 50 years, it is to be hoped that scientists will solve the problems of mimicking nature, making it possible to move from today's top-down methods to bottom-up manipulation of individual atoms and molecules (European Commission, 2009).

In recent years, virtual manufacturing is becoming widely accepted but several definitions are attached to these words. Virtual manufacturing concepts originate from machining operations and evolve in this manufacturing area. The general idea is that Virtual Manufacturing (VM) is nothing but manufacturing in the computer but literature review reveals that business models for virtual manufacturing are lacking in general. According to Kim et al (2004), VM is used in order to meet competition, reduce costs and shorten the time for new product entries. The aim of VM is to integrate diverse manufacturing related technologies. VM enables a business to optimise the development of new products and manufacturing processes. VM opens up great strategic possibilities for benefits (Karlsson, 2005). A study by Shridhar and Ravi (2002) suggests that VM is an integrated, synthetic manufacturing environment exercised to enhance all the levels of decision and control. The strong influence of virtual manufacturing on business performance shows strong demand for new business models that are in tune with the emerging trend in manufacturing.

A business model is an abstract representation of some aspect of a firm's strategy; it outlines the essential details one needs to know to understand how a firm can successfully deliver value to its customers (Seddon and Lewis 2003). ICTs certainly enable individuals and firms to relate together and organise in more complex forms, like networked organisations which then presents more complex business modelling challenges. Complexity of businesses has increased over the years with the introduction of information and communications technologies (ICTs), outsourcing, globalisation and the associated rethinking of how firms can operate. The proper construction of a model reduces the complexity of the subject modelled from the bounded rational modeller's perspective

Osterwalder et al (2005) defines a business model as a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams. Thus one could argue that business model analysis is widely applied in the context of strategic, financial and operational decisions by firms. This view conforms to the recommendation by Manufuture Forum.

Kuang and Gao (2007) observes that information systems play a critical role in today's manufacturing business, and the need for enterprise-wide integrated information system has grown rapidly. Although there are different integration approaches reported in the published literature, in today's industrial practice, most of the information system integration projects are still done on a trial-and-error basis owing to the lack of practical and feasible integration methodologies.

Chang et al (2002) suggest that firms should invest resources and time to develop a set of manufacturing capabilities to fit into their business strategies. The role of manufacturing information systems is to support, amongst other things, sequencing of manufacturing and business processes. It should also support enterprise business strategies, not constraining them in any way (Browning and Ramasesh, 2007).

According to Choong (2006), an integrated manufacturing information system is an integrated system of manufacturing technologies and business strategy into an information system. It is a strategic tool for achieving competitive advantage, which enables firms to respond quickly to market changes, achieve flexibility of products and processes and manage the complexity of today's manufacturing environment.

According to Moran and Meso (2008), when corporations fail to recognise the relationship between manufacturing strategy and corporate strategy, they become burdened with seriously non-competitive production systems, which are time consuming to change.

Roth and Miller (1992) argue that the linkage between manufacturing success and business performance is indirect. To link manufacturing to overall business performance requires management to exploit manufacturing capabilities. The established linkage is: manufacturing success is linked to managerial success is linked to economic success. Superior manufacturing only improves the odds of relative business success; it is up to general management to seize the opportunity generated by a successful manufacturing.

According to Younus et al (2009) a Manufacturing Execution System (MES) supports shorter product cycles with high quality and low cost. The MES is also responsible of the comprehensive scheduling of manufacturing activities in the production system. It launches work orders, track production activities and quickly respond to random events. MES not only be implemented in the batched process industry but it can also be implemented in any manufacturing industry with a minor adjustment according to the requirement of the other industries. The current global trend is pushing for sustainability in manufacturing. In one of their latest publications, Rockwell Automation (2009) discusses the need for integration between MES and sustainability initiatives.

Any manufacturing business shop floor model has to have a hierarchical integration and control mechanism for optimization. These hierarchies exist in any manufacturing business regardless of existing information systems and are crucial for the performance of the manufacturing operations. The hierarchical model needs to demonstrate how goals and tasks are handed down to lower levels. Huang (1996) suggests that goals need to be broken down into individual tasks and resources need to be allocated accordingly.

According to Bauer et al (1994), there is also a definite need that would orchestrate seamless operation. This is done through regular feedback mechanism down the line that ensures monitoring and control at the individual and team level for which the planning horizon may range from milliseconds to months. At the enterprise level the hierarchy is responsible for the mission of the enterprise to be followed by facility/plant, shop, cell down to equipment level having different but interrelated functions and responsibilities (Langer et al 1999).

Manufacturing systems are moving toward distributed management nowadays because centralised management is susceptible to changes in demand and equipment condition.

Nowadays companies pursue variable-variety, variable-volume production to adapt to dynamic and fast changes in the quantity and models being produced. A typical example is the cell production system (Swamdimass and Darlow, 2010)

This is a shift from the small variety large volume manufacturing era, which is represented by the Ford Production System of the U.S. Recent trend also suggests full utilisation of human capacity through passionate consideration of human characteristics in manufacturing. Shiotani (2007) studied the industries in Japan and found that human-centered manufacturing system emphasises on flexibility and control by the operator to satisfy varied needs of the buyer/customer thus accommodating short term changes in varied demand or in other words customization. He has also noted an emerging trend in the cell production systems based on human-centered framework and an environment-conscious manufacturing.

Aytac (2003) found that a human-centered manufacturing system also serves as a springboard for better teamwork through knowledge sharing. People are considered as one of its most valuable assets for a company to gain a competitive position in the market - through flexibility, quality and efficient production. However, the manufacturing information system has to integrate the current and predicted business environment information (both internal and external) into the system to formulate the appropriate business strategy. Management would then have to set KPIs (key performance indicators) for manufacturing and business alike to improve overall organisational competitiveness. The organisation has to ensure a customer-facing competitive position at all times through cross-functional consultative process and regular informal/formal feedback mechanism. Accordingly a framework for integrating business strategy into manufacturing information system is vital. Thus it is evident that both internal and external business environment drives business strategy and manufacturing information system and therefore they need to be integrated (Chattopadhyay et al, 2010f). This is contrary to the view of traditional technocentric design which tends to see people merely as an extension of machines, and as a source of error and unreliability in production.

Selen (2000) viewed organisations as entities designed and driven by people. He also emphasises the importance of the organisation to change as a result of the open knowledge sharing among employees. Haight and Kecojevic (2005) observe that humans provide



characteristics such as judgment, flexibility, adaptability, experience, and sentient knowledge (feel for the process) and are therefore essential components in industrial systems. Gungor and Gupta (1999) believe that today's manufacturers should construct and design inverse manufacturing systems consisting of assembly and disassembly systems for environmentally-conscious manufacturing. According to Yamada (2008), such inverse manufacturing and disassembly systems have already been constructed and are being operated in Japan to produce and recover various kinds of products such as recycling of cameras, copiers, computers etc. Jaychandran et al (2006) suggest that manufacturing engineers need to consider additional environmental factors in process selection such as material waste, tool change or disposal, raw material consumption, landfill costs, waste storage and disposal costs, by-product material reuse and by-product material contamination etc as precursor towards sustainable manufacturing.

The Global IMS (Intelligent Manufacturing Systems) initiative is essentially aimed at realising the sustainable globalization of manufacturing industry (Westkamper et al, 2000). One of the objectives is based on the cooperation among industrial nations towards the development of 'next-generation' techniques, human and environmental sustainability.

Any manufacturing operation has to be supported by an efficient and current business model driven by strategy and vice versa. This particular need is in tune with the global trend for future manufacturing say 2020 and beyond. Although some authors had discussed the need for a human-centered approach or for sustainability in manufacturing and/or reuse of materials, they are mostly in different contexts and fall short of a comprehensive approach to a strategy-driven business model for a manufacturing. Business modelling issues have been dealt in the past by various authors but a comprehensive approach to develop a framework for business models for virtual manufacturing enterprises has not been addressed as such.

## **2.10 Globalisation**

The idea of a global economy is not new. Wide globalisation-related legal and political issues notwithstanding, organisations at their level have no choice but to acknowledge a global economy, hence a global market; and they must ensure that they have the capacity to

survive in such an environment (Boone and Ganeshan, 2001). They must become global organisations, because they may discover that their products and services are needed and welcome at the other end of the world, or because if they don't move, competitors will come and find them on what they perceive as their "own territory"; or else simply because if they don't acquire a global mindset, they will be deserted by qualified employees, and soon will find themselves unable to function at all. According to Kersiene and Savaneviciene (2005) a truly global organisation requires a whole new mindset, a new culture, a new way to work. In a global organisation, people are not recruited anymore on the basis of such criteria as gender, age, religion, nationality, location, financial, social or hierarchical status, but on the competencies they can bring to help achieve the organization's goals. These people do not select their employer anymore on the basis of such criteria as nationality, location, size, facilities, but on its vision, goals, corporate culture, and capacity to help them fulfill their own aspirations (Duanmu and Fai, 2007).

A prerequisite to this new situation is that organisations must develop and integrate the tools that enable global work. The point is to have an information structure that, as simple and small-scaled as it maybe, is fully integrated, compatible, and accessible from anywhere. But this is not enough: for these tools to be useful and to generate value, they must be used optimally by the employees, through a real "people/technology" partnership (Euwema et al, 2007). This requires not only that people know how to use their technological tools, but that they have the ability to grasp, and adapt to, conceptual and operational realities at different levels and in different cultures, i.e. they need to be global-minded (Ferdows, 1997).

The emergence of the digitally networked world economy has already been eroding geographic boundaries. The issue here is not simply the increased permeability of borders or the increased mobility of capital, technology and information in an electronic age but the irrelevance of the territorial sovereignty (Flynn and Purchase, 2001). Hence, globalisation and its consequences on the organisation, in mindset if not in activities, have an impact on its people and all other management areas.

Firms will have to cooperate across whole manufacturing systems instead of competing individually as technologies become more complex. Whereas "Monodzukuri" spirit presents a path toward the attainment of sustainable economic development, one which enables growth that acknowledges environmental load, depletion of natural resources, and

population issues. As part of the Third Science and Technology Basic Plan which sets six policy goals, the promotional strategy in the 'Monodzukuri' technology field mentions human-centered manufacturing practices as a basic policy. It selects ten issues as major research themes, seven of which include keywords relating to humans or the environment.

Business modelling helps to democratise decision-making when it is diffused throughout the organisation. When accessible data is combined with easy-to-use analysis and modelling tools, frontline workers, who are properly trained, suddenly have sophisticated decision-making capabilities. Decisions can be made more quickly and problems resolved as soon as they crop up (Hammer and Champy, 1993). This does not, however, provide any specific reference to the business model for virtual manufacturing as such. However, business models themselves are complex and not well understood. They lack a formal basis that would facilitate both description and comparison. Models of businesses are also an abstraction of the complex socio-technical systems.

According to Tennent and Friend (2005), business models are commonly used for:

- Financial planning that quantifies the impact of a business decision on the balance sheet and the income statement.
- Forecasting driven by accurate historical and current business environment data
- Mapping processes in a visual representation of the resources required for a task and the steps to be taken to perform it ( task planning, allocation & control)
- Data mining to dig out unpredictable relationships between variables from the silos

In the context of globalisation, enterprises need to develop their products and manufacturing processes while improving their skills in order to remain competitive in the new markets, but they must also find new opportunities resulting from technological developments and globalisation. Encouraging adaptability and structural change to sustain the competitiveness is essential, especially in the light of increasingly strong competition from emerging economies, such as China or India.

The global economy is in the midst of a radical transformation with far-reaching and fundamental changes in technology, production, and trading patterns. Faster information flows and falling transport costs are breaking down geographical barriers to economic

activity. The boundary between what can and cannot be traded is being steadily eroded, and the global market is encompassing ever-greater numbers of goods and services.

Globalisation is essentially a process of deeper international economic integration that involves:

- A rapid expansion of international trade in goods and services between countries
- A huge increase in the value of transfers of financial capital across national boundaries including the expansion of foreign direct investment (FDI) by trans-national companies
- The internationalization of products and services by large firms
- Shifts in production and consumption from country to country – for example the rapid expansion of out-sourcing of production

Another way of describing globalisation is to describe it as a process of making the world economy more interdependent. The expansion of trade in goods and services, the huge increase in flows of financial capital across national boundaries and the significant increase in multinational economic activity means that most of the world's economies are increasingly dependent on each other for their macroeconomic health. Globalisation no longer necessarily requires a business to own a physical presence in terms of either owning production plants or land in other countries, or even exports and imports. For instance, economic activity can be shifted abroad by the processes of licensing and franchising which only needs information and finance to cross borders.

As a result of globalisation business models are changing at a faster pace. There are two key areas in a business model description: the story and the numbers (Magretta 2002). Business models do not work because they fail either the narrative test (the story doesn't make sense) or the numbers test (profit and loss) does not add up. Rappa (2000) further extends the business model that spells out how a company makes money by specifying where it is positioned in the value chain. The author identifies twenty nine different types of business model, in nine categories. Hedman and Kalling's (2003) business model is also detailed, but again gives a static view of a business model - despite all the evidence that initial business models are often unsuccessful, and need to keep being modified until a viable

model is found. These researches have highlighted various aspects of business modelling in general but without specific application to manufacturing.

The term "model" has been used extensively in systems theory. Betz (2002) used such an approach to define a business model in systems terms, with inputs, processes and outputs clearly identified. Afuah and Tucci (2000), on the other hand, provide a complete taxonomy of web business models without referring to manufacturing businesses. Chesbrough and Rosenbloom (2002) point out that while the term business model is often used these days, it is seldom defined explicitly and specifies revenue generating mechanisms and competitive strategy as keys to functions of a business model.

Hence, enterprise architectures and modelling techniques of the nineties have already lost grounds being out of date and are incapable to face up to the challenges of the current and upcoming business complexities with already shifting global landscape in manufacturing. This justifies the need for a concerted, multi-disciplinary, new, innovative and non-traditional approach to enterprise modelling and their frameworks that would be able to withstand the harsh business realities of the 21<sup>st</sup> century.

## **2.11 Value Sphere Disaggregation**

In some extreme views, researchers argue that in a couple of decades, one would see that the integrated firm as a transitional structure that flourished for a brief moment in history (Tapscott et al, 2000). They suggest that the fundamental unit of the economy may be reverting from the corporation to the individual. Independent contractors, rather than full-time employees in big companies, will perform most work. Such networked human atoms will join fluid and temporary virtual structures through webs to design, produce, market, and support goods and services. The large corporations like telecom companies, banks, power companies, and other utilities are shrinking the number of traditional jobs. Meanwhile, the bulk of economic growth originates with small businesses increasingly through Webs.

Large corporations of today are operating in a globally distributed environment and diversified in many different industry sectors. The enterprise structure and hence management and control of the corporation is getting too complex. There is an increasing trend that these large enterprises are disaggregated into autonomous or semi-autonomous

units which are controlled by a holding company (Day and Wendler, 1998; Williamson, 1996). These units are themselves registered companies of their own right and have a range of complimentary core capabilities. The holding companies have a lean core leadership organization and highly flexible enterprise architecture with nodes to hook 'on' or 'off' these autonomous units on real time basis. Using advanced communication technology, management of the holding company and the autonomous units can connect 'any to any' on 24/7 basis. These disaggregated autonomous units then become independent tiny companies. This allows the holding company to minimize its on-going operating and overhead costs. However, the lean enterprise might not have ready capabilities to cover all their business needs. In order to minimise cost of new projects, the holding company will look for the disaggregated autonomous units and other more competitive micro-businesses which are able to provide similar services. With improvement in broad-band connectivity and more ferocity in competition, one will soon see an online global directory of small organisations that would comprise of entrepreneurs, consultants, contractors, and so on. The holding company will be able to pick the best brain in the world so that the geographical barriers are not an issue any more (DeFrancesco, 2000).

The idea of disaggregation also has the effect of restructuring the organization into forms that increase the effect of motivating members and coordinating their activities more effectively (Langlois, 1990; Osterloh et al, 2002). With a smaller, autonomous structure, individual units are expected to be more innovative and quick in response.

However, the policy of corporation disaggregation brings problems that cannot be resolved with traditional enterprise management methodologies (Cowen and Parker, 1997). Some of the problems of disaggregation without proper enterprise modelling methods to support it are lack of specialised investments in physical or human assets since negotiating, monitoring and enforcing contractual safeguards is likely to prove costly. Subcontractors, subsidiaries and temporary agencies often have no collective bargaining institutions or are covered by different firm-level and sectoral agreements. This could provoke chances of collusion among the disaggregated units

Corporations spinning off parts of their business to the disaggregated units are likely to reduce or surrender their ownership interest. It is also generally believed that the knowledge challenge is more operational than strategic. An inability to share knowledge effectively

means that though one business unit is aware of an opportunity, others are not, and the moment is lost (Zenger and Hesterly, 1997). Due to these problems of disaggregation, significant amount of research in enterprise modelling has been developed in recent years in order to understand its operations and processes and to improve system effectiveness and efficiency.

Integrating human atoms through Web is more difficult for Value Chains such as manufacturers. But individuals and small firms frequently participate in less structured, more creative areas of shop production like industrial design. For example on eBay, an entire virtual project team may put itself up for sale. These people in a project team could shift from being independent human atoms to a more fluidic structure through the Web equivalent of a larger molecule and remarket their capabilities as a strongly associated group of individuals (Allen et al, 2008). In case of a possible disaster, the forces that bind them would weaken and they would disperse to reform with other molecules or group of other human atoms in a different situation.

Traditionally, managers in the hierarchy deliberately fostered their firm's culture: the values, norms, and mission of the firm that grow from, reflect, and influence the thinking and behaviour of its people (Handfield and Bechtel, 2002). People outside the organisation, however, always see it as *modus operandi*, ways of working, business processes, policies and management styles and so on. Aggregations and Value Chains are more hierarchical, passing down vision and strategy and usually a top down approach.

In the past, companies controlled their own cultures. In the information age many employees use another company's Web portals communications system for larger parts of their day and become exposed to someone else's culture through a very powerful and influential medium. Due to engulfing net culture of the 21<sup>st</sup> century many companies, irrespective of their size and operations, are global by definition. Internetworked human atoms speak many languages and appear in many colours and are globally dispersed (Henderson and Venkatraman, 1993; Coleman and Papp, 2006). Sensitivity to language and cultural norms enhances collaboration and vice versa.

In the digitised world today suppliers participate and compete through Net rather than firm versus firm, and function as partners rather than adversaries (Hofstede and Minkov, 2010).

As information moves in lightning speed undue secrecy between partners, win-lose negotiating, and an insistence on exclusive supplier/partner relationships are fast outmoding orthodox industrial-economy thinking. Cisco insists on open financial results with its supply-chain partners. The open sharing of information, combined with a single information system for all its supply partners, ensures that all draw on the same data at the same time. This minimises unnecessary inventory (Holweg et al, 2005).

In today's competitive world everyone must be accountable for contributing to end-customer value. Business processes have to ensure customer satisfaction at each stage, from product design to post sales services and support. The customer's role is important in value creation. Customers (also human atoms) become economic units creating and depleting value, exchanging value and setting value goals, which are met by value propositions. In disaggregated value chain customers design and co-service the products (Li, 2007).

Setting aside the debate, it is already known that human atoms, use their brain power, and their know-how that constitute a form of capital that in many ways surpasses the value of cash and other traditional capital assets. They also bring energy, capacity for innovation, relationship capital as well connections with customers, suppliers, and other partners (Mathews, 2006). They may also bring a strong experience with new business models. In the 21<sup>st</sup> century organisations need to rethink how to attract retain, nurture and energise human atoms, especially in the internet-economy.

Business processes contain implicit norms, values, and business practices that govern the deployment of human atoms. Therefore such processes may be perceived as Lego-like software "objects" standardised and are reusable in different situations as product of human skills, resources and real time information (McCreery et al, 2004).

Porter (1985) describes issues of architecture, relationships and trust in terms of the concept of value chain linkages. Value generating activities are not independent but interdependent. Linkages are relationships between the way one value activity is performed and the cost or performance of another. The structure of the value chain may be monolithic / integrated or disaggregated.



In a disaggregated value chain structure the key value generating activities take place across units or locations within and number of independent organisations acting as suppliers, distributors, producers within a network architecture or structure as the progress of creation of the product or service moves towards its final exchange outcomes (Morden, 2004).

Johnston and Lawrence (1988) describe the disaggregated value chain (DVC) as a value adding partnership (VAP) that work closely together to manage the flow of goods and services along the entire value added chain. Some of the advantages of DVC are minimisation of organisational complexity and bureaucracy, ability of any individual within units or between a number of independent organisations in the chain to concentrate and specialise only on its core competence and the flexibility or agility to change constituent entities according to particular customer needs. One of the important requirements of DVC is the need for high and sustained level of trust amongst individuals within a business unit and members of the VAP.

The world changes a lot in an hour if not in minutes. Demanding and aggressive customer expectations also change. So does supplier capacity. Change is eternal and therefore inevitable in all walks of life. The best supply chain for each given order will be created individually based on the order itself. According to McFarlan et al (2007), Li & Fung's network of 8,300 suppliers stands ready like the famous Qin terra cotta soldiers that guard the emperor's grave in Xian. A specific supply chain is called forth in response to the demand of the customer at that moment. In a network-centric configuration of modern enterprises, knowledge workers are able to create and leverage information to increase competitive advantage through the collaboration of small and agile self-directed teams (Van Alstyne, 1997).

To cope with these changes, the new, “flat” world is one where technology and collaborative economies have fostered equity in access of information for everyone working in the same business. Anyone can send email to anyone. The internet contains tremendous amount of information open to anyone for searching. This freedom of information flow enabled by new information technologies has created an entirely new playing field.

According to Friedman (2005) the enabling technology, individuals, and organisations skilled enough would take advantage of currently available new platforms along with the

sudden influx of more than three billion people from the emerging economies onto this new, more leveled playing field.

Chinese and Indian companies have emerged in the era of a “Flat World,” in which easily accessible global supply chain flows through dramatically reduced barriers to world trade and provide a platform unavailable earlier for the manufacturers in both countries to build market share world-wide (Zeng and Williamson, 2007). Whatever is happening now both China and India will continue to impact global supply chain strategies to an even greater degree for probably decades to come in a globalised world interconnected with new internet technologies since the playing field is now relatively flat.

McDevitt and Van Hise (2002) proposed the atomic views of supply chains manifesting its vibrant characteristics due to people in their hearts who radiate their sphere of influence onto the business environment that is extremely difficult to model. Human interactions are basically interactions between different humans through their respective spheres of influences in personal, social and working life where emotion also plays a very significant role. The uniqueness of human participants is what creates variety in human interactions and emotions that is very difficult to model and/or simulate. As compared to 6.8 Billion human population of the world today, it is therefore impossible, if not absurd, to classify and/or group human emotions (similar to atomic number in periodic table). Uniqueness amongst diversity of enterprises makes it very difficult to classify and/or group them in a single table for modelling purposes like periodic table. At the core of a flat supply chain a human network orchestrates material, information, logistics and transportation, material handling, customer needs and transaction flows in order to ensure seamlessly integrated and synchronised operation.

## **2.12 Conclusion and Research Methodology**

The clustered literature review as above suggests that there are gaps in research which are not explicit. This justifies the need for identifying those gaps. To address these gaps one could undertake different research methodologies. This dissertation has adapted enterprise modelling as a tool to address these gaps. The gaps are multidimensional. For example the concept of Enterprise Architecture, Enterprise Reference Architecture and Micro-

architecture and so on are very confusing and send mixed messages to the researchers. These gaps are reflected and addressed through modelling in the respective chapters (3 & 4) in detail. It is felt that it is more relevant to address them in respective chapters rather than in the literature review. As a result the methodology as discussed hereunder had to be adapted to go by inductive and qualitative research methodology

During the literature review it was also revealed that current EA's and enterprise theories are too specific in certain aspects of enterprises in the 21<sup>st</sup> century. Some of the problems associated with these EA's are:

- Static and basically focused on information or form of enterprise
- Holistic and multi-disciplinary approach lacking
- Very few Industrial applications /case studies available
- Not suitable for service industries
- Complex with information silos
- Contradicting schools of thoughts
- Unable to address modern business complexities
- EA usage declining world wide
- Most industries already have their own EA
- Most line managers unaware of EA benefits
- Lacks common language and so on

In order to understand the problems associated with the existing EA methodologies it became necessary to visit few companies in Australia. The outcome of this research necessitated further visits to other countries. Accordingly China and India were chosen since both countries currently being the two fastest growing economies in the world and are geographically closer to Australia Figure 2.1.

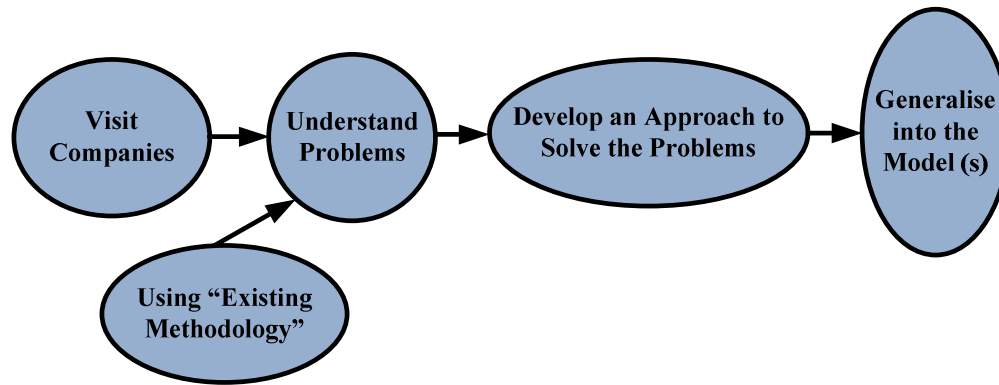


Figure 2.1 Research Methodology

The initial objective of these visits was to gain first-hand experience on the status of EA usage in these countries and also establish industry contacts so that subsequent case studies could be undertaken. The second objective was to consolidate the research findings from the case studies and generalise them into the model(s) and finally apply the newly developed model(s) back to industries for trialling and validation.

The details of the methodology for data collection and analysis are discussed in Appendix 1.

Literature review reveals that there are practically no case studies in Enterprise Modelling except one on Fluor Daniel and few others mostly on furniture, pushbike manufacturing SME's etc. Therefore comparison between enterprise models between developing and developed countries could not be investigated and as such was beyond the scope of this research.

## **Chapter 3      People-Centric Model (PCM)**

### **3.1 Introduction**

An enterprise is a collection of resources assembled for the purpose of pursuing and executing some explicit or implied mission or objective. An Enterprise may exist to pursue an economic, political, social, or religious mission or objective or a combination thereof. As discussed in Chapter 2, EA is the fundamental base for guiding modelling and analysis. Hence, it is important that an enterprise in the 21<sup>st</sup> century has an enterprise system that enables its employees to work in joint ventures and distributed locations around the world.

This research has investigated whether there are any inherent reasons within the theory of enterprise engineering that prohibit application of enterprise architectures to industry. The seminal work on the use of PERA methodology to model the engineering company Fluor Daniel (FD) by Rathwell and Williams (1996) is a good example of how enterprise architecture can be applied in a process industrial environment. Since then, there is no further publication in this area exploring how the enterprise architecture can be used in companies of similar nature. Since the nature of business of WorleyParsons (WP) is similar to that of Fluor Daniel, this dissertation intended to apply PERA to model of a similar Engineering, Procurement and Construction Management (EPCM) company of today to see whether the methodology is sufficient to perform the modelling task today as compared to two decades ago.

### **3.2 Modelling Approach for WP by PERA**

WorleyParsons (WP) is an Australian-based leading EPCM company providing technical, project and operational support services to customers in the hydrocarbons, minerals and metals, power and infrastructure sectors. With 118 offices in 38 countries and 31,000 employees worldwide, WP lists some of the world's largest energy companies as clients. As resource projects continue to grow in size and complexity, WP is one of the few global companies with the resources, technical capabilities and systems to meet the demands of large-scale projects (<http://www.worleyparsons.com>). Headquartered in Australia, WP has

annual revenue of A\$3.5 billion. Half of WP's business is related to contract alliances, typically in the form of long-term partnership with a global energy provider.

This research studied WP's enterprise model using PERA.

### 3.2.1 Architecture

Figure 3.1 and 3.2 depict the application of PERA methodology to WP as it is and compared to the original PERA model as applied to Flour Daniel (FD). It is interesting to note that the three pillars configuration FD-PERA is not applicable to WP. The production equipment column is non-existing thereby reducing the WP-PERA into a two column structure.

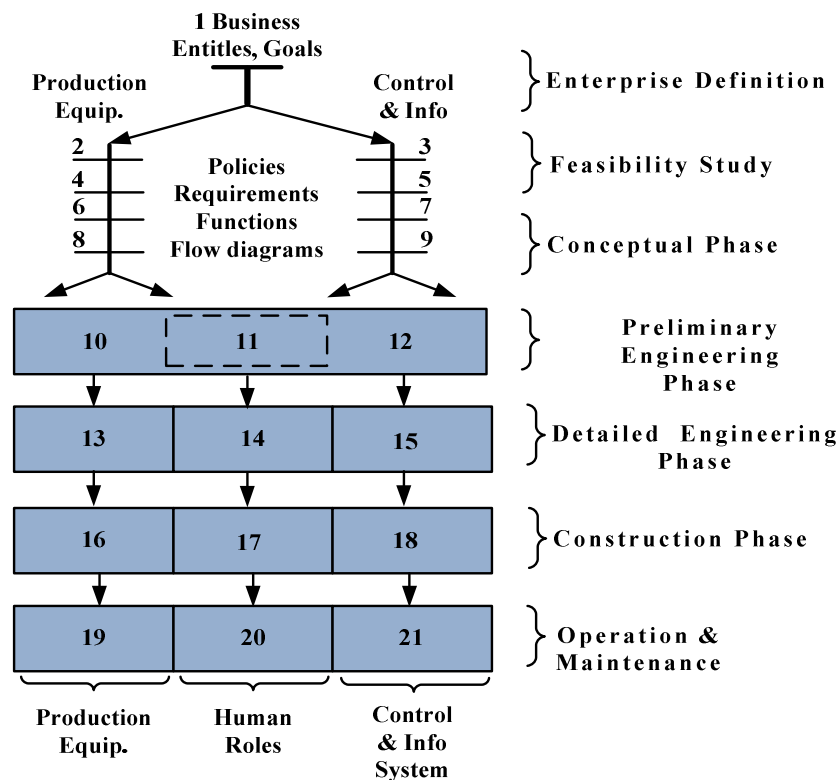


Figure 3.1 PERA model of Flour Daniel

FD is an engineering, procurement and construction company which serves clients in all types of industries, including process and discrete manufacturing company. Moreover, the Fluor Daniel case study was applied to a manufacturing facility that required the construction of piping, instrumentation and control equipments, etc for a typical process

control system development project during its construction and commissioning phases. FD also owns a number of manufacturing facilities around the world. The resulting model has a complete set of three column architecture with defined life cycle processes of Information Systems, Human Organisation and Manufacturing Equipment functions.

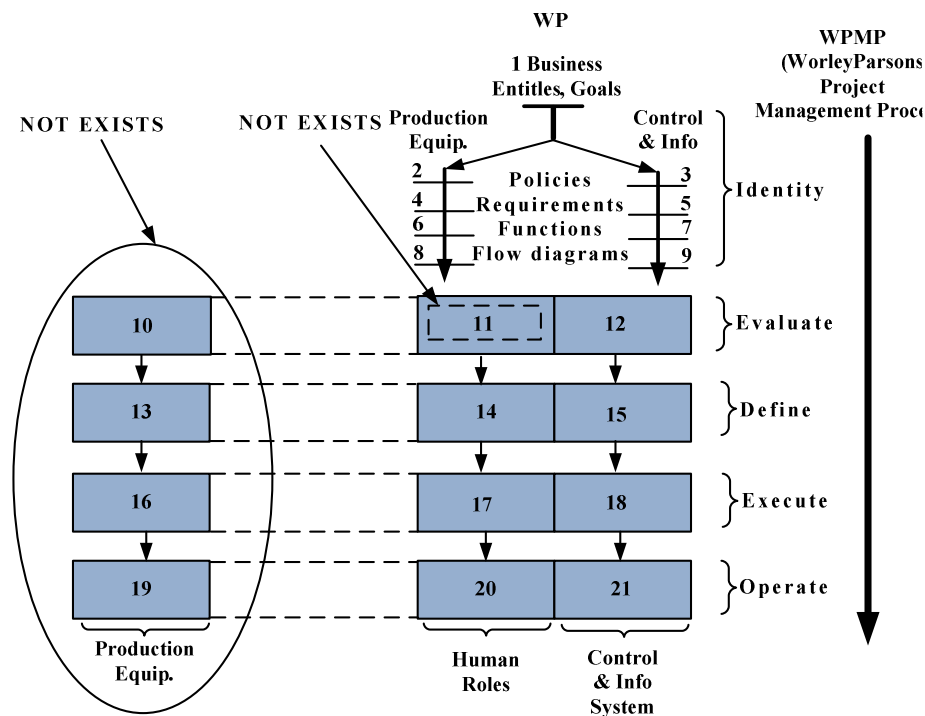


Figure 3.2 PERA model of WP

Contrary to FD, WP does not have any manufacturing facility at all. Their upstream and downstream projects in the oil and gas area (hydrocarbons) are carried out from inception to commissioning as per contracts from their clients. Being an EPCM company, WP provides essential management and technical expertise to the contractors during the construction phases of their projects. They do not have any manufacturing facility of their own, nor do they have any machinery and production equipment for construction activity of their projects. Constructions are done by sub-contractors who have their own engineering, technical and management supervision. Hence, the manufacturing equipment architecture in the FD-PERA model does not exist in WP-PERA.

### **3.2.2      *Life cycle concept***

PERA is based on division of phases in a project organisation. In the old days of limited email and Internet access, the engineering team was required to overcome the issues of communication and work synchronization. Hence a phase divided project could provide certainty and risk detection within a large project team.

In today's environment, software vendors are knocking on doors with a variety of product portfolios starting from MYOB (Mind your Own Business) to MRP (Materials Requirement Planning), ERP (Enterprise Resource Planning) and SAP (Trade Mark software for ERP) to cater for the bottom to the top end of the market. Furthermore, Web 2.0 is the norm of business activities in the 21<sup>st</sup> century. These new IT products are able to compress the processing time of different enterprise tasks in a much shorter timeframe. PERA has a deep root in computer integrated manufacturing (CIM) which is fundamentally a sequential process. The step by step enterprise architectures based on the concepts of CIM, process control and automation become out-of-sync when the use of new information technologies force many of these sequential processes to occur in parallel.

### **3.2.3      *Role of human***

Since WP does not have any discrete manufacturing facility, the manufacturing equipment architecture is not relevant as is true for any service oriented industries. Comparison of the two PERA models reveals that the humanisation and automation boundaries (in the cell No.11) should be purely human roles in the WP model. Human system design should therefore start from the beginning of the enterprise life cycle but the PERA methodology does not allow this to occur until the implementation stage Figure 3.3 and 3.4.

Today's enterprises are exposed to unpredictable and harsh global business environment. The factors contributing to the current situation are many and complex in nature such as economy, globalization, and fluctuations in exchange rates and so on.



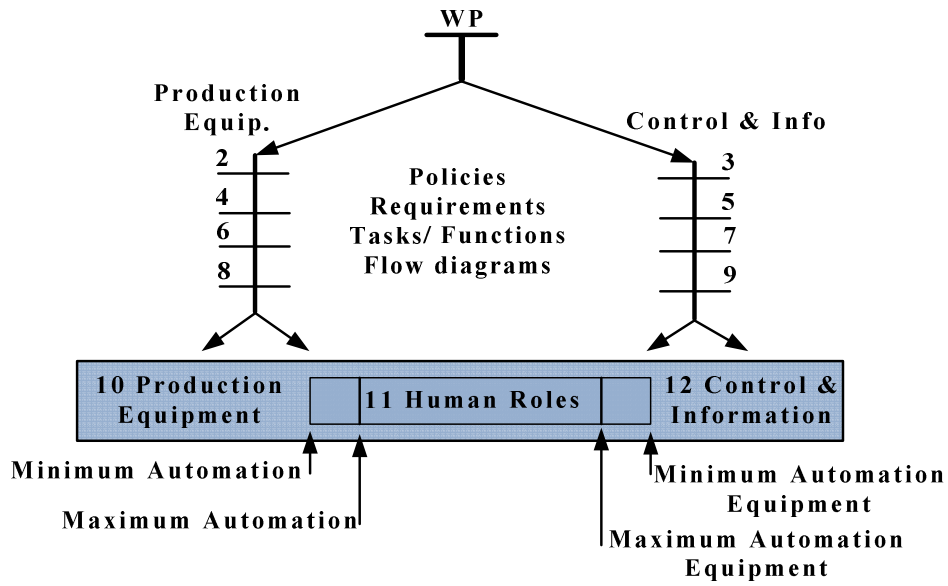


Figure 3.3 Human Role in standard PERA

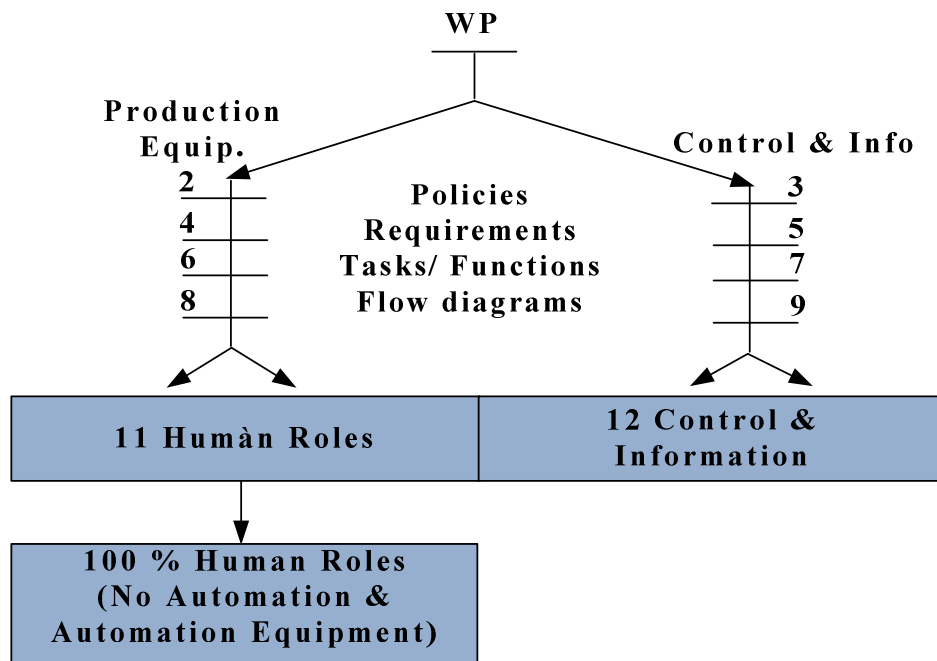


Figure 3.4 Human Role in WP-PERA

Hence, enterprises are much more vulnerable to the harsh business climate as of today and this trend is likely to continue in the near future. It is now an accepted fact that ICT (Information & Communication Technology) would continue to revolutionise and influence

the basic socio-economic fabric of this planet in order to combat against ever increasing customer expectation and demand under increasing market volatility.

### **3.3 Motivation for a new enterprise model**

The research project at WP found that due to changes in business environment and new legal and cultural framework, there is a severe deficiency in PERA that makes it impossible to provide complete enterprise architecture for current multi-national enterprises (MNE's). This dissertation argues for a new enterprise architecture framework that builds on prevailing enterprise architecture theory but extends to incorporate elements that are essential for describing contemporary enterprise activities.

#### **3.3.1 *Acceptability of current enterprise models in industry***

The vast number of architectures with diverse views in the last two decades posed difficulties for the enterprise designers and practitioners to carry forward the commendable work for developing effective and efficient enterprises. The fact is that one hardly finds adequate industry applications, case studies and/or validation reports of the three main architectures (CIMOSA, GIM and PERA) in the literature. The author noted through continuous dialogues with the industries and academics in Australia, Europe, India and China that the enterprises of today need to be modelled through a need based, consultative and cross-functional approach within an acceptable timeframe, affordable cost and justifying the bottom line profit. It has been further observed that there is a general lack of awareness of the benefits and applications of enterprise modelling and related fields amongst various industry practitioners ranging from healthcare to banking, insurance to consulting, and from manufacturing to logistics/supply chain service providers and so on.

These findings also corroborated with the current survey report by Institute for Enterprise Architecture Developments (IFEAD, 2003-05). The low uptake of enterprise architecture (EA) in industry as evident from the IFEAD report defeating the very purpose of creating enterprise architectures for guiding enterprise design and implementation processes generates further curiosity for a researcher to explore the current status of Enterprise Architecture usage not only in Australia but also in the two upcoming superpowers China

and India. Questions have been asked, particularly in the applicability of traditional enterprise architectures to new engineering oriented business environments of the 21<sup>st</sup> century.

### ***3.3.2 Fundamental changes in modern organizational characteristics***

It is observed from WP that the fundamental trend in ICT revolution would always be driven by human for human and the entire workforce consisting of scientists, engineers, technologists and labour are at the helm of this revolution. They are all human – a unique living entity, not a mere resource. This creates the preamble of the classical (decades old) debate on humanisation and automation. Automation would certainly creep in to those tasks which are repetitive and have cost leverage but would never be able to erode the fundamental need of human. There is, however, no denial of the fact that manual tasks will diminish at a much faster rate in the years to come but none of the tasks would ever become 100% automated. Hence, 100% automation in each and every phase of the socio-economic lifecycle is impossible if not absurd. They would always remain a hybrid mixture in varying degree depending on the need, application and economy of scale. Therefore the role of human is pervasive throughout the enterprise and that must be reflected in the EA.

### ***3.3.3 Flexibility and continuity***

Global enterprises of today are much more complex as compared to those two decades ago and this trend is likely to continue over an unpredictable future. An integrated enterprise-wide architecture should be able to cope with the fast changing business environment influenced by the ever changing needs and relations with the customer and boundaries. There is a paradigm shift in thinking towards greater collaboration and sharing of resources in this context as is witnessed globally. Substantial growth in micro-enterprises, Small and Medium Enterprises (SMEs), e-Enterprise along with associated risk and security issues, ever increasing competition and volatile global economy and so on are forcing businesses to become more flexible, adaptive and zero-latent.

PERA focuses on the technicality of system development and process engineering. It does not cover the increased complexity of businesses in recent years, including risk, quality assurance, procurement economics, customer relations management, supply chain

management and many other parallel business processes. In the WP modelling analysis, it is observed that a typical EPCM business in the 21<sup>st</sup> century requires significant degree of flexibility in the enterprise architecture to deal with a wide variety of customer expectations. The system also requires substantial certainty of continuity in both operations and inter-connection within its business environment. These characteristics must be built in the company's operating system when it is designed from enterprise architecture.

#### **3.3.4      *Integration with revenue and cost models***

Cost of skills, resources and time are absolutely critical for any enterprise especially for a service oriented enterprise such as WP that bills customers against man-hours. The bottom-line for sustainability and survival of any business is to have a cash flow through transaction of goods and/or services in exchange. Therefore any job or project can be viewed as an outcome of a number of well coordinated and synchronized tasks, in the micro-level, that need to be accomplished against a given time-frame (schedule). For any task the time allocable for its completion determines both the levels and variety of skills (people) and resources (tangible and intangible).

Hence, skills, resources and time become the determinant factors for the assessment of cost for any task towards production of goods and/or services. For any enterprise unit costs of production of goods and/or services have a direct bearing on the margin for given revenue. For example lower the cost of production higher is the margin of profit and vice versa. Therefore, revenue and cost models are an indispensable consideration for any enterprise architecture. Unfortunately, there is no such architectural construct in the WP-PERA model.

#### **3.3.5      *Requirements of new enterprise architecture***

An enterprise architecture methodology must be designed to produce specified, predictable results. It must specify not only "What to do" but most importantly, "How to do it" and "Why". Moreover, it must be based on a set of concepts and principles that theoretically, logically and empirically establish a basis for producing an aligned, integrated, responsive, flexible EA that is capable to design, engineer, manufacture and/or implement an enterprise. A methodology which does not comply with these criteria is not useful.

The PERA methodology with its deep seated root in computer integrated manufacturing (CIM) might have been suitable for Fluor Daniel but there are issues when it is applied to model WP. The deficiencies appear to be more vivid when considered under the context of new operating practices in the heavily ICT assisted engineering and services businesses. Table 1 compares the characteristics of WP-PERA and the enterprise modelling requirements for WP's case.

<b>WP-PERA</b>	<b>WP enterprise model requirement</b>
<b>2-pillar structure</b>	<b>Hybrid sequential and parallel pillars structure</b>
<b>Line of automation</b>	<b>Not applicable</b>
<b>Human Role in the context of automation</b>	<b>Human Role in the context of organization culture</b>
<b>GERA Life Cycle Phases</b>	<b>Embedded in WP management plan</b>
<b>Does not address quality, risk, safety, etc in architecture</b>	<b>Must be addressed in the enterprise architectural construct</b>
<b>Master planning, sequential processes</b>	<b>Strategic planning, hybrid processes</b>

Table 3.1 Deficiencies of PERA in modelling WP

### 3.4 Modelling considerations and views

An enterprise is perceived as living because of its people. It is driven by people and exists for customers who are also people - the end user or beneficiary of a product or service. Information flow and communication acts as a glue to hold people together having a common goal and purpose.

People use their skills, knowledge (tacit and explicit) and resources as available to them (tangible and intangible) to produce individual outputs. In units of time, these outputs are products and/or services or parts thereof. This is true for everyone in the enterprise irrespective of their position in the hierarchy. At the macro-level, the working units are groups of people, often called teams. At the micro-level, the working units are individuals with different roles. Irrespective of levels, the outputs are the product of skills, resources and time.

To serve customers, strategically any enterprise must have some kind of organisation structure in operation. In fact a customer focused strategy drives a continual changing structure and restructuring of any organization today (Cascio, 2005). A strategy driven, customer facing organization involves customer ‘end to end’ during its entire project life cycle. This justifies the need to include all functions, disciplines, resources and above all its people and their skills in any model. People act on information provided to them. Hence, information flow is vital to hold various elements in cohesion. This concept forms the key considerations for developing the People-Centric Model (PCM), which consists of the following elements:

#### **3.4.1      *People***

A People-centric enterprise has a primary focus on people, not processes. It is vitally important that an organisation creates an environment where people can create, embrace, implement and live with innovative ideas and relentless effort for continuous improvement.

People are the most valuable and precious resource. A people-centric organisation not only engages people’s heads but also reaches their hearts and inspires them to create value for the customer by creating extraordinary levels of trust and sense of fulfillment.

In developing the PCM, the focus will be on how people are engaged, assigned, allocated, managed, developed, recruited, synchronized, etc in the model. It is logical that PCM puts the people element at the centre of all operations.

#### **3.4.2      *Organisational Structure***

Organisational structure is seldom contemplated by most people working in organisational settings and it needs to be aligned with its business strategy. It is critical both for a company and its employees.

Benefits and pitfalls of a number of organisational structure options should be examined prior to implementation. The PCM must embrace information that helps enterprise designer to explore options without jeopardising the long term goals of the enterprise since they

pertain to the long-term success of individual employees and the company as a whole. In the long run, organisational structure can spell the difference between success and failure for a company, as well as for the individuals who work there.

### **3.4.3 Strategy**

Strategy is the direction and scope of an organisation over the long-term: which achieves advantage for the organisation through its configuration of resources within a challenging environment, to meet the needs of markets and to fulfill stakeholder expectations. Strategies exist at several levels in any organisation - ranging from the overall business (or group of businesses) through to individuals working in it.

### **3.4.4 Enterprise Architecture (EA)**

EA broadly defines a firm's needs for standardised tasks, job roles, systems, infrastructure, and data in core business processes. Thus, it helps a company to articulate how it will compete in a digital economy and it guides informed decision making to realize their vision of success. EA's vital role is in enabling or constraining the execution of business strategy.

### **3.4.5 Customer**

Outsourcing the understanding of one's customer is not how an enterprise develops a customer-centric culture. An organisation can outsource its coding, design and writing or any other back-office jobs but cannot outsource understanding of its customer. It is the most important skill of the 21st Century. Those who have a deep understanding of customer needs and behaviour, and translate these needs into effective people-centric solutions and services are likely to succeed because that's how it creates value. Getting to know customers is crucial. The more technological the society becomes the more important is such knowledge.

### **3.4.6 Information Flow**

When computer and communications technologies are combined, the result is information technology, or "InfoTech". Information Technology (IT) is a general term that describes any

technology that helps to produce, manipulate, store, communicate, and/or disseminate information. There are mixed consequences of IT on environment. Each wave of technology creates a set of waste previously unknown by humans e.g. Cyber Waste. Some technologies are designed specifically with the environment in mind, but most are designed first for economic gains.

#### **3.4.7      *Synchronised Material Flow***

Traditional facilities, most often, conventionally run plants that will produce relatively large batches, which will move sporadically in response to prioritised dispatching and expediting at universally heavily loaded resources. Emphasis will be on keeping resources and people busy rather than on keeping material moving.

When work is properly scheduled to get the maximum, uninterrupted performance at the most constrained resources, and when material release is controlled and properly buffered to sustain that performance without building unneeded queues of work at the less constrained resources, a factory will achieve optimal overall performance. Throughput (product produced and shipped) will be maximised; work in-process and finished goods inventory will be minimised; and the level of operating expense needed to support these positions will be lowest. Under such conditions work will flow reliably, with minimal attention and effort, in relatively small quantities, and at relatively high velocity.

A strategy driven, customer facing, properly designed and IT enhanced EA could offer an alternative but efficient solution to such problems.

#### **3.4.8      *Feedback***

Feedback is the dynamic process of presenting and disseminating information to improve performance. Feedback mechanisms are increasingly being recognised as crucial elements for organisational governance. Key (and often underutilised) resources of knowledge in organisations are the data and information that emerge from monitoring systems, analysis, conclusions, and recommendations. Learning organisations have sophisticated ways of designing evaluations with learning (as well as accountability) in mind with systems that



ensure outputs of self and independent evaluations are made widely available, used to question orthodox thinking, and trigger creativity and innovation.

### **3.5 The People-Centric Model**

Recent paradigm shift in thinking, under the current global context, is forcing the enterprises of today to become more flexible, collaborative, directive, decentralized and geographically dispersed with shared resources in multi-country locations. Traditional responsibility related and vertically integrated organisations are fast disappearing since the hierarchical structures do not work anymore. This research proposes the People-Centric Model (PCM) in order to address some of deficiencies in WP with PERA reference architecture. Chattopadhyay and Mo (2010b) have provided the modelling structure. This chapter describes the four fundamental structures in details in the following sub-sections.

#### **3.5.1 *Hierarchical Global Decomposition***

Any project or service oriented enterprise views a task, near a potential customer, through a decomposed hierarchical structure to optimise its cost and speed of delivery for improved customer relationships management. A consultative process at the global, regional or country level is initiated right from the bidding stage of the prospective project (Figure 3.5). Increased competition, push for lower cost for customer conceived quality and logistics/supply chain costs are closely looked into prior to execution of the project. At the micro-level of operation any job or project is viewed as a number of well coordinated tasks through different views.

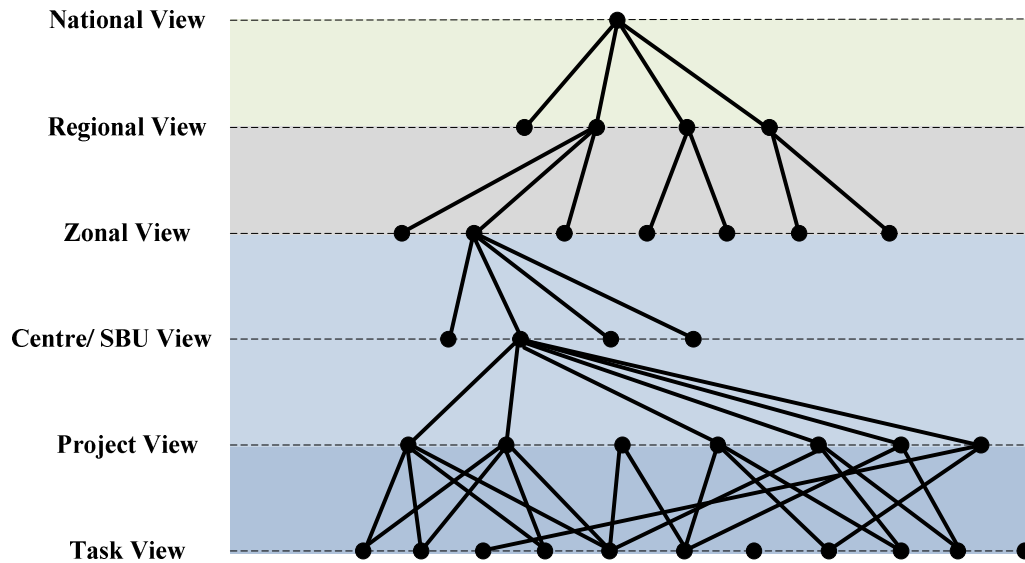


Figure 3.5 Hierarchical Global Decomposition

The effect of global decomposition of tasks in this hierarchical structure is to allow the global organisation to distribute work to the most appropriate engineering units with matching expertise. Such global decomposition is made possible with new ICT such as video conferencing, computer supported working environment and more significantly, with increased bandwidth and system mobility (e.g. wireless connectivity). This enterprise architectural construct provides a framework for the global enterprise to define an optimal set of human roles across the organization.

### 3.5.2 *Hierarchical Task Decomposition*

An EPCM company with multi-country operation takes a holistic view for any new project or prospect since their core skills and resources are dispersed globally. Depending on the location of the customer, they can mobilise all their global resources for execution of the mega-projects nearer to their clients. Being a service oriented enterprise they offer all sorts of expertise and skills in relation to engineering, procurement and construction management but do not own or have any manufacturing facility as such.

Hence, having defined human roles in the global management context, the task view needs to be further decomposed in terms of detailed implementation and operation. Current management practices emphasise the need for a cross-functional team approach to optimise

resource utilisation and increased productivity. A job or project is thus further evaluated by both top-down and bottom-up views as in Figure 3.6.

This consolidates the consultative process across the whole enterprise. The task view is the technical view of the work to be done. It depends on the work breakdown structure that many large international projects are usually based on. The hierarchical task decomposition view is created by the chief engineer in charge of the project, and devolves to different work packages that individual engineering units are required to perform.

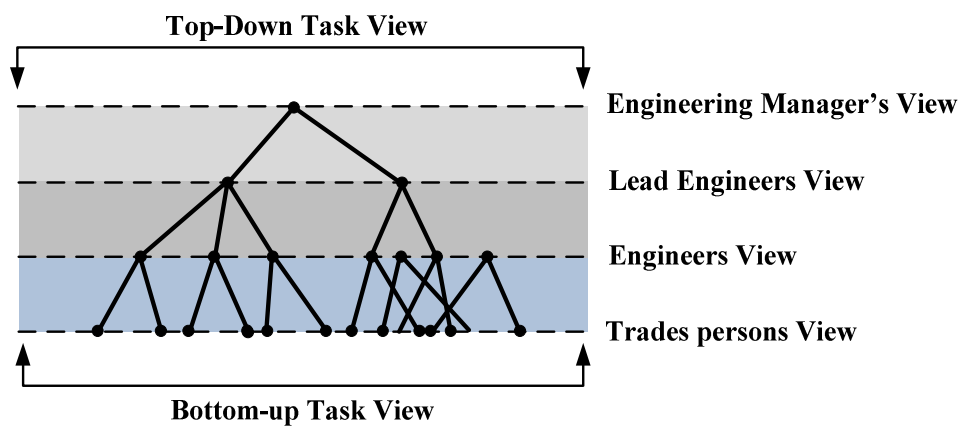


Figure 3.6 Hierarchical Task Decomposition

This view forms the foundation of work allocation, outcome monitoring, key performance indicators (KPI's), tracking and reporting and so on.

### 3.5.3 *Kaleidoscopic View*

The kaleidoscopic view looks at the holistic approach of the enterprise towards resources and human skills that are available at the Strategic Business Unit (SBU) level. The kaleidoscopic view includes modern complexities of both internal and external business environments such as risks, quality, procurement, construction, logistics and supply chain management (SCM), customer relationships management (CRM) and so on. These are the functions that are not considered in traditional EA's. The customer's view is analyzed by various cross-functional teams and overseen by both the SBU and customer for monitoring progress and control purposes Figure 3.7.

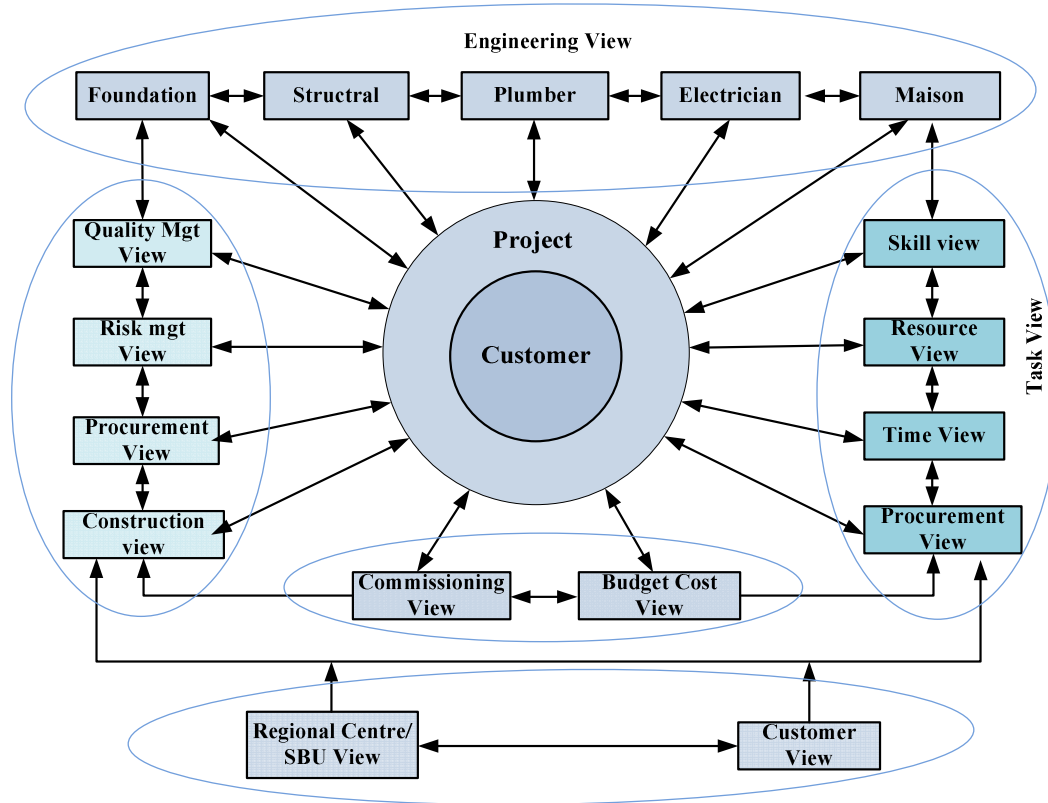


Figure 3.7 Kaleidoscopic View

A customer's view at the regional, centre or strategic business unit (SBU) level is managed by CRM practices. The project requirements are viewed by all stakeholders from engineering design to commissioning at every phase of its lifecycle. Diverse views are aligned through regular consultative process through formal and informal feedback at all times with the spirit of collaboration and sharing. This enables the global enterprise to achieve its objective and meet their goal with utmost efficiency as shown in the kaleidoscopic view. The engineering view is composed of various engineering departmental views according to specialisation or discipline such as structural engineering, process engineering, electrical engineering and instrumentation and so on.

The task view is analysed from the project management perspective. At the micro-level, any task is accomplished through maximised utilisation of available skills and resources (tangible and intangible) at any given point of time. This also determines the intra- and inter-engineering department task flow. It is also obvious that the time factor is very critical

throughout and has a direct bearing on the cost of delivery to customers which in turn determines the efficiency of the taskforce.

The kaleidoscopic view is very important since it represents the holistic approach to project governance. This view also helps to integrate the non-technical aspects of a global project in areas of quality, risk, procurement, construction, commissioning, budget and so on. Project control and monitoring are embedded within the 'gates' system of various stages.

Therefore, the kaleidoscopic view conforms to the view dimension of the GERAM modelling framework (Bernus and Nemes, 1994).

#### **3.5.4      *Resources View***

Traditionally, resources in enterprise architectures refer to physical resources and people. However, an enterprise is perceived as living because of its people. It is designed and run by the people and exists for satisfying the needs of end customers/consumers who are also people.

Information flow and communication hold people together having a common goal and purpose. Humans are the only living entities in any enterprise, 'uniquely' unique by nature and the costliest resource amongst all others in its category. The heart of any enterprise is its people interacting with others through individual sphere of influence including the crucial one, the customer. Therefore, its EA should structure itself encompassing all stakeholders both internal and external. Therefore the resource view of EA should form the focal point of all EA design and implementation activities.

The resources view in the PCM (Figure 3.8) puts people (and their skills) as the binding strand for two other resources: time and physical resources (i.e. equipment). Without the existence of people, there is no concept of time and equipment. People play the pivotal role in any organisation and their presence pervades through all layers of the organization from shop floor to the board room.

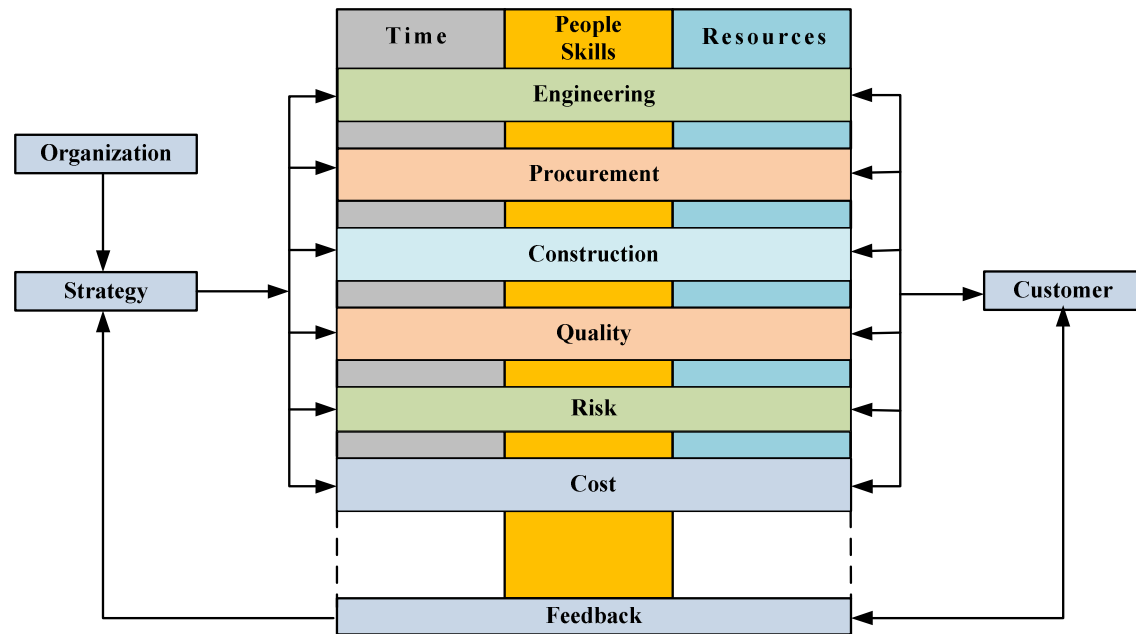


Figure 3.8 Resource view

People use their skills, knowledge (tacit and explicit) and resources as available to them (tangible and intangible) to produce individual outputs. In units of time, these outputs are products and/or services or parts thereof. This is true for all people in the enterprise irrespective of their position in the hierarchy. At the macro-level, the units of outputs are therefore the product of skills, resources and time.

This model has a number of layers which are, for a typical EPCM company, engineering, procurement, construction, quality, risk and so with the 'feedback' (both formal and informal) layer common to all other layers and has been shown with an extended dotted line. The extended dotted line represents the expandability and flexibility amongst various need based layers that differ from industry to industry. The layers and their numbers would be different according to the function, organisation structure, its size and type (manufacturing or service), workflow and so on. Any enterprise has to have its own organisation structure, strategy and customer. In fact a customer focused strategy drives the structure and restructuring of any organization today.

### **3.6 The PCM applied to WP**

WP has a people-centric organisation culture and as such its operation is pivoted on people and its culture. Trust and responsibility with authority empowers a project owner at WP. Hall (2008) described the primary business objective for WP is to design, oversee and manage immense complex and risky projects to foster strong relationships between the company, its stakeholders and the clients.

WP has a strong global presence in its specialized field and is well supported by its own Global Business System that integrates its operation. A salient feature of the Global Project Delivery Systems and Tools is WorleyParsons Project Management Process (WP-PMP) that is based on a phased and gated project development process with clearly documented project value objectives and value improving practices. Decision support package requirements are fundamental to what is planned for and delivered in each phase. Process is scalable for small and large projects. Project risk classification and services type determine “project category” and associated system requirements.

WP believes that the fundamental of successful project execution is the definition of the Work Breakdown Structure (WBS) that provides the framework from which the project management and project control systems will be set-up to facilitate the tracking and reporting of the project status and cost. It facilitates all aspects of engineering, procurement and construction for the execution of all projects undertaken by the Company.

As the customer will normally use this same structure during the operations phase of the facility, the customer may have a pre-configured WBS that will have to be complied with. For any new project (green or brown oilfields), WP takes a global view which is then decomposed into country, centre, SBU (Strategic Business Unit) and ultimately to task level in the Global Hierarchical Decomposition.

A task is further decomposed to the macro-level in the hierarchy of every discipline involving cross-functional teams. Stipulated standards and procedures are strictly followed, monitored and controlled for each project lifecycle. Continuous improvement is embedded throughout right from kick-off stage to operate stage of the project in direct consultation

with the customer to ensure on-time delivery and minimize project overruns. WP has meticulous customer relationships management (CRM), supply chain management (SCM), budget and cost control policy and procedure in place. The kaleidoscopic view developed at different levels depicts the process flow view of the project (Figure 3.9) as seen by all stakeholders of WP (both internal and external).

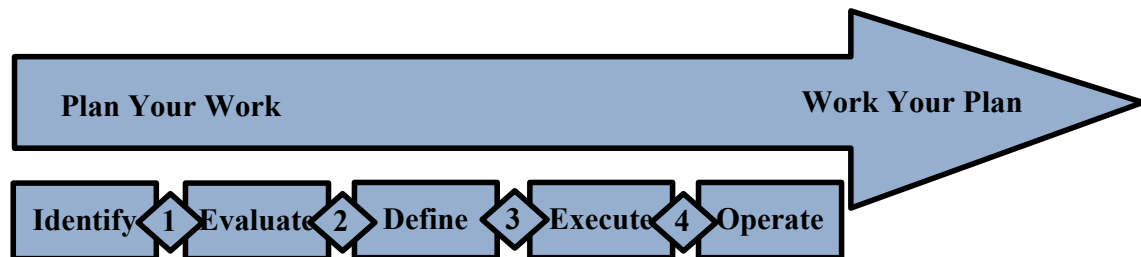


Figure 3.9 WP Process Diagram

These levels represent various functional departments as layers with scope for further expansion and flexibility as shown by a pair of extended dotted lines. All these layers are held together by people with the support of resources where time is a critical parameter. The number of variables thus get reduced to only three (People, Resource and Time) thereby simplifying the effort on enterprise engineering and integration.

The modelling flow in Figure 3.10 enumerates a step by step approach to derive the PCM. In general, the following steps are required in order to design and build an EA:

- Identify the current state (AS-IS) by describing the enterprise structures and activities as an EA. Information including how IT is being used in the organization, what manufacturing or business technologies is being used and how they are deployed to add value to the organisation.
- Document the desired future state (TO-BE), where the business would like to be from an EA perspective, taking into consideration the current initiatives involving use of enterprise resources.
- Document the "gap" between the AS-IS and TO-BE states and construct a list of projects and initiatives to close the gap, in other words, develop a "transition plan".



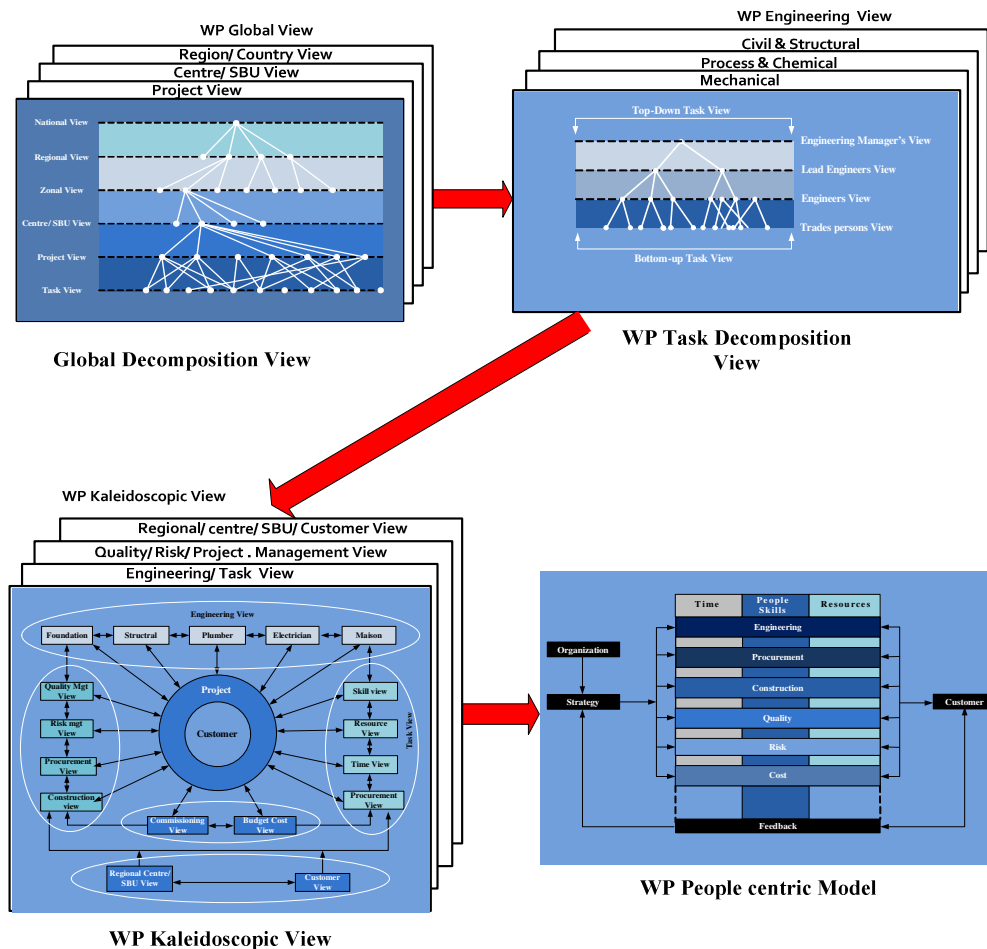


Figure 3.10 Modelling Flow at WP

This EA transformation process is not necessarily a linear process and each phase of this process may trigger changes in preceding phase's therefore continuous evaluation and feedback is necessary during the entire system life cycle development.

Constant changes in the business environment will also alter the content and priority of many of the IT projects. Other reasons are the changing strategic plan of the business, competition, laws, regulations, and economic pressures. All of these factors must be taken into consideration while designing and building the EA. Finally an EA is not any good if other managers and members of the cross-functional teams in the company are not aware of it. By educating them with the roadmaps for technology, they can make better decisions.

### **3.7 Chapter Summary**

People play the pivotal role in the People-Centric Model (PCM) with pervading presence in all layers of the EA in the organisation from shop floor to the boardroom. A global EPCM company with large skills and resource base of their own is able to enhance their capacity by operating through a pool of experts, consultants and suppliers from various engineering and management disciplines. A customer-oriented organisation involves customer from 'end to end' of the project the life cycle. This justifies the need to include all functions, disciplines, resources and above all its people and their skills in the architecture. In essence this modelling methodology is universally applicable to all enterprises manufacturing or service irrespective of their size and type. In that sense it is generalised.

## **Chapter 4      Molecular Model**

### **4.1 Introduction**

The PCM is task oriented and good for modelling project based enterprises. However, in a manufacturing environment, people can move anywhere in the organisation according to the functional needs, tasks and priorities and/or any other business requirements. These fast transitions by people add new dimension to their roles and relations within the organisation and outside. The dynamics of human interactions at individual, group or cross-functional team level become very complex and intricate. Contradicting and often conflicting situations may arise very often that need to be resolved by making impromptu hard choices. The dynamics of such complex relationships between people, resources and time need to be modelled in the organisation. In order to model such complexities one has to focus at the micro (human) and macro (organisation) architectural level of the organization. It is necessary to model an enterprise not only at the micro architecture level but also at the macro-architecture level in which the supply chain and its partner enterprises are required to interact with the social, business, government and community.

One of the objectives of this research is to compare enterprise models between Australia, China and India in order to analyse manufacturing systems in multi-country locations. Accordingly a case study was undertaken at GEW Corporations in Hong Kong. The motivation for the development of the Molecular Model came from the case study at GEW and discussions with the various academics in Australia, China, India and Europe.

GEW Corporation Ltd is a well-established electrical appliance manufacturer distributing its products worldwide. It has its seat in Hong Kong and a production plant with some 2400 employees in Dongguan, China - mainly for export shipment production. GEW exports mainly to Europe and North America and is an OEM (Original Equipment Manufacturer) & ODM (Original Design Manufacturer) electrical heating appliances manufacturing company for brands like Philips, AEG, Toshiba, Kenwood and Sanyo (Yip, 2008).

Many companies have been outsourcing their manufacturing operations off-shore due to comparatively cheaper labour and material cost further leveraged by lower local transport,

logistics and supply chain costs and so on. The lean core corporate leadership of GEW in Hong Kong holds the factory in Dongguan, China as their wholly owned asset and directly controls the manufacturing operations there. The glue to such control in manufacturing operation is through an extended ERP (Enterprise Resource Planning) system connecting Hong Kong office to Dongguan factory. The local management in the factory, in turn, is connected to a number of loosely-coupled small manufacturer, entrepreneurs, and contractors and so on. These loosely-coupled small units are neither partially nor wholly owned asset of the Hong Kong office. The lean core leadership nucleus in Hong Kong might have a thinly wired link, indirect influence and/or control over these loosely coupled units through their Dongguan factory.

The study shows that the 21<sup>st</sup> century organisations are born in a flat world that is bi-dimensional (physical and virtual) and borderless where the ability to access information is so tremendously increased that people can free themselves from the traditional communication channels. People-to-people networking are gathering pace globally with the ever advancing web and communication technology. A new breed of tiny, autonomous, loosely-coupled organisations is going to influence the global business equation of the 21<sup>st</sup> century arising out of growing availability of experts, suppliers, consultants, and small manufacturer and connectivity between ‘any to any’ on 24/7 basis. This phenomenon cannot be explained by the PCM.

This chapter examines a manufacturing enterprise that uses different levels of enterprise architectural construct to fulfill its missions and goals.

## **4.2 Motivation for a new model**

In the third millennium, the fundamental unit of the new economy is not the corporation but the individual. Tasks are not assigned and controlled through a stable chain of management but are rather carried out autonomously by individuals and independent contractors. These electronically connected individuals join together in fluid and temporary networks to produce and sell goods and services. When the job is done, the network dissolves and its members become independent agents again, circulating through the economy, seeking the next assignment (Malone and Laubacher, 1998).

In a molecularised economy, each consumer is a market segment of one and is enabled by networked technologies. The organisation's info-structure must therefore be molecularised, support the production of molecular solutions, and stimulate molecular work altogether. As relationships grow more business-like between employers and employees, the traditional chain of command are breaking, and the hierarchy-linked authority and power that used to be taken for granted are now being questioned. The industrial, command-and-control hierarchy and economy are giving way to molecular organizations (MO) and economic structures.

The new enterprise has a molecular structure based on the individual and adapts its work centres accordingly. The knowledge worker (human atom) functions as a business unit of one motivated, self-learning, entrepreneurial workers. The customer (atom as well) interacts with the organisation and demands fulfillment of unique needs. The new organisation requires more free dynamic relationships among these human atoms.

The term molecularisation under this context usually refers to the cybernetic characteristic that qualifies the tendency of any entity/activity/technology to adopt molecular structure small, flexible, adaptable and expert units that are capable of functioning independently or gather temporarily depending on the expected benefits (Shipley, 2003).

While undertaking a field study at GEW a mental model was first conceived under the backdrop of the literature review for a MO (Section 2.7). The following sub-sections now develops a pathway from concepts of atoms, molecules, elements and compounds to MO's in order to develop a generic framework and methodology for modelling such MO's with proper artifacts and formalism.

The shortcomings of the already established molecular theory, as is evident from the literature review, lie in its inability to address the design aspects of enterprise architectures that are fundamental to achieve cohesion in the organization by improving management efficiency. This research is motivated to apply the established principles of chemical science to create a generic enterprise model for the upcoming trends for the molecular organisations (MO) of the 21<sup>st</sup> century.

### 4.3 Molecular Organisation (MO)

Despite commendable efforts by various researchers on issues related to disaggregated molecular organisations, a scientific analogy of molecular structure, their properties and reactions as applicable to such MO's have not been addressed. Further explanations in regard to how these MO's would function and interact in real business environment are also lacking in the research attempts. Among the missing concepts are the fundamental chemical ingredients: elements, compounds, atoms, molecules and bonding that explain the basic principles of chemical reactions, which is analogous to business transactions between enterprises. Comparing humans with both atoms and molecules at the same time does not seem logical in the analogy as drawn by researchers. The specific issues of structure, properties and interactions of the MO's while drawing analogies from the concept of atoms, molecules and their interactions has been briefly explained by Chattopadhyay et al (2010e). This chapter expands the theory in details.

#### 4.3.1 *Human atom*

This dissertation takes the view that human organisations consist of a more fundamental element, viz. individuals that have certain similar characteristics and yet can differ from one another due to different levels of expectations (Maslow, 1943). The chemical analogy is that human atom provides the input characteristics to business organisations which are then operating in various scenarios involving supplier, customer and cross-functional teams.

As businesses and people become more disaffiliated from corporations, group models become less useful. Molecular, individual-based models become the focus. One would need to think less sociologically and more psychologically. Technology will continue to evolve and reduce the costs of outsourcing, but people must also acquire the traits of "modularity." This means as the number of business interactions increase exponentially, those who can maintain quality of interaction will gain competitive advantage. Those who can rapidly forge relationships with other individuals to create new businesses will prosper. And those who can connect with others and create new and larger networks will also be successful.

Interpersonal skills are becoming more strategic. This doesn't mean just first-order communication skills like listening or giving feedback. It means far higher-order capabilities

i.e. mindsets for rapid trust creation, self-confidence and low levels of self-orientation in pursuit of customer focus.

Trust, for example, will migrate from "corporate" paradigms of reliability and credibility into other aspects of trust like authenticity, sincerity and other-focus. Customer orientation must migrate away from database-based conceptual models like CRM (Customer Relationship Management) to truly personal-driven models in which CRM is a minor enabler. Customer focus must come to be seen as a consciously chosen psychological state, not a business process.

In the evolving networks of business and of people individualisation and personal selling is already dominating in mass customisation for manufacturing and one-to-one marketing.

#### **4.3.2      *Producer/Customer Atom***

Fundamentally an enterprise is created, designed, maintained, transformed and even decommissioned by its only living entity "people". The premises of an enterprise (say a building or a factory shed) devoid of people are mere concrete jungles, deserted and dead. All inanimate attributes of an enterprise from mission to structure are irrelevant without people. Therefore one can argue that people are the only unique, living, animate, and yet the ultimate building block of an enterprise like the way atoms are for matter. Some of the unique properties of a human atom are:

- Capacity to identify, receive, store, analyse, transmit and interpret data/information. It can also transform received data into explicit and tacit knowledge and can innovate
- Enormous flexibility, agility, resilience, adaptability, and mobility
- A self-controlling and self-sustaining complex adaptive system capable of constantly exerting and manifesting their own sphere of influence to the external environment
- Capable of performing at different energy levels (like different electron shells/orbits in an atom) depending on the nature and magnitude of the internal and external stimuli
- From the system point of view human atoms can be considered as independent, standalone, intelligent and effective information and communication system by themselves.
- On its own merit a human is a living enterprise by itself.

A human atom accesses resources (R) and information (I) available in its closest orbit/shell as ‘input’ and then apply its skills(S), also closely held in the same orbit/shell, to produce tangible/intangible ‘output’. A supplier human atom spends its energy to push a product forward from raw material stage to finished goods stage against all latencies in the manufacturing facility. Latency here means resistance and/or delay of all kinds from the facility and the environment it operates under the constraints of bottlenecking, machine set up times, management indecision and so on. The situation resembles the loosely bound electrons in the outermost orbit of a ‘Donor’ atom before forming an ‘electrovalent bond’ with another ‘Acceptor’ atom.

Temporal aspect of energy spent in a shell/orbit as the ‘output’ is depicted in Figure 4.1.  $E_1$  represents the energy content for Shell/Orbit1 at time  $t_1$ . Similarly Shell/Orbit 2 has higher level of energy content  $E_2$  at time  $t_2$ . Human atoms spend energy  $E = E_2 - E_1$  between time  $t_2 - t_1$  in order to produce the output P at the next higher energy level in Shell/Orbit 2 (where  $E_2 > E_1$  and  $t_2 > t_1$ ).

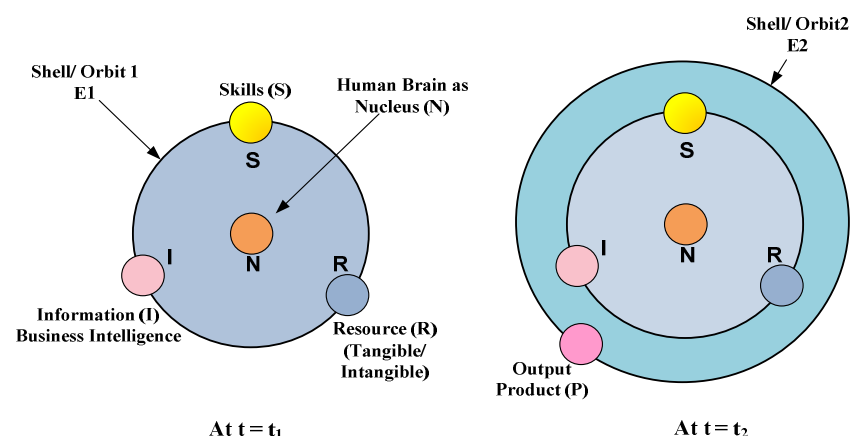


Figure 4.1 Human Atom as Producer/Supplier

On the other hand a “Customer Atom” is also a person, company or any other entity that buys goods and services produced by the “Producer Atom”, company or entity. The customer atom has a need, desire or demand (H) to acquire, consume or use a product or service (P). The human customer atom can get its need/demand (H), in its outermost shell /orbit, satisfied by the output (P) supplied by the producer/supplier-human atom. From the



basic principle of economics, a business transaction is said to be completed when P (supply) satisfies H (demand) (Figure 4.2).

A human atom whether as supplier/producer or customer has similar structural properties in terms of nucleus, orbits and so on to that of an atom. A human atom changes its role between supplier producer and customer depending on the business need. Thus a supplier (human atom) in one situation could become a customer (human atom) in another situation and so on (structural similarity).

The resources as used by the supplier atom might be either tangible or intangible or both and the information/knowledge could be either explicit or tacit knowledge or a combination thereof. A typical business transaction can therefore be viewed as the transference of goods or services from the producer human atom to the customer human atom that is in need of the particular product or service.

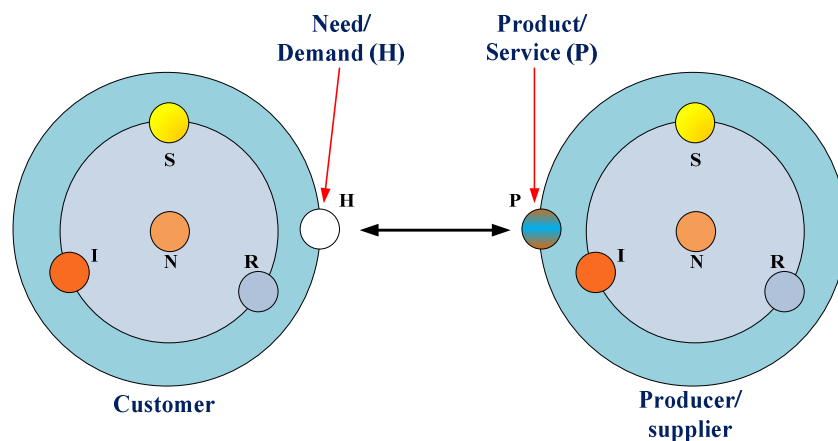


Figure 4.2 Human Atom (Producer/Customer) – Product satisfying demand

Under such ‘Give’ and ‘Take’ scenario a demand gets satisfied by the supply and P gets eventually infused with H ( $P = H$ ). The infusion of supply with the demand by respective producer and customer human atoms is visualized in Figure 4.3.

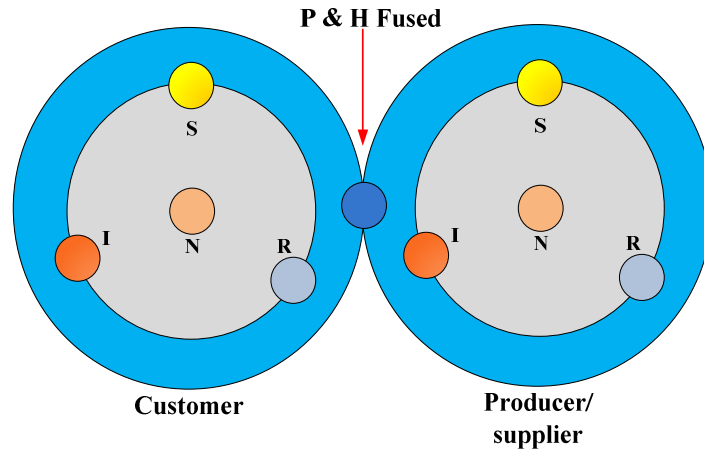


Figure 4.3 Human Atoms (Producer/Customer) – Infusion

In case of collaboration, however, the formation of a ‘covalent bond’ between supplier human atom and the customer human atom could be deemed through ‘sharing’ of R, S and I. Mutual commercial interest ‘of-a-kind’ still remains the key enabler amongst partners. Both human atoms (supplier and customer) have structural commonalities like having a nucleus (brain with entrepreneurship instinct) in their centers as nucleus and produces a tangible/intangible output through innumerable permutation and combination of their resources (R), skills (S) and information/knowledge (I) that are closely held in their innermost shell/orbit as ‘wholly owned’ assets.

Revenue can be interpreted as the cost of transference of P to H. The cost incurred by the producer/supplier is interpreted as the cost of energy spent to produce the output (product or service) to satisfy the need of another customer human atom.

When visualised with the concept of atomic structure, at individual level, people with their brain as nucleus are atoms that use the resource and information as available around them (in various orbits) to transform the raw materials to finished goods with the help of their skills. Chattopadhyay (2010a) examined the supply chain structure in China and found that a business transaction may be viewed as completed when the output, as produced by human atoms (individually or collectively), satisfies a customer (also human atoms). Therefore humans, as producer/supplier and or customer, resemble similar structural features like atoms when visualised as fundamental building blocks of an enterprise.

As the value adding operational activities mature towards completion, incremental human energy is continuously spent by the human atoms to collectively transform raw materials to finished products.

#### **4.3.3      *Bonding in cross-functional teams***

A common building block of redesigned organisations is a cross-functional team responsible for a definable output. Surveys also suggest that the incidence of such autonomous cross-functional teams is expanding (Gordon, 1992; Mehta, 1994; Verespej 1990). Hence, a cross-functional team is a group of human atoms who share their resources (R), skills (S) and information (I) to fulfill the goals, objectives and mission of an enterprise. Being living and dynamic, the cross functional teams can quickly reposition themselves around a prioritised job and project. An individual human atom can join or leave a team or function independently as may be the case or desired by the lean core leadership at the nucleus of the MO's.

In cross-functional teams the concept of 'covalent bond' (sharing electrons), as applicable to formation of compounds between two or more dissimilar elements for example water (H<sub>2</sub>O), holds good.

For example electrovalent type of bonds exist in a mentoring, training or coaching relationship between human atoms within the team when tacit knowledge can flow down from one 'donor' human atom to another 'acceptor' human atom. Thus a hybrid mixture of both types of bond (electrovalent and covalent) is present amongst human atoms in cross functional teams. Human atoms apply and share both explicit and tacit knowledge, tangible and intangible resources and their skills to accomplish a task around a cash flow or opportunity.

Chemical analogy of covalent bonding in Benzene could be taken as an example here. Benzene is an organic compound (C<sub>6</sub>H<sub>6</sub>) with equal number of Carbon and Hydrogen atoms (six each) arranged in the form of a hexagonal structure, popularly known as 'Benzene Ring'. Carbon atoms are alternatively held by three covalent bonds within themselves and each Carbon atom holds a Hydrogen atom in its other hand remaining free (also covalent bond) Figure 4.4.

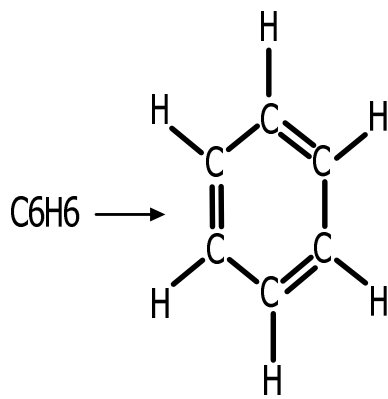


Figure 4.4 Benzene Ring –  $C_6H_6$

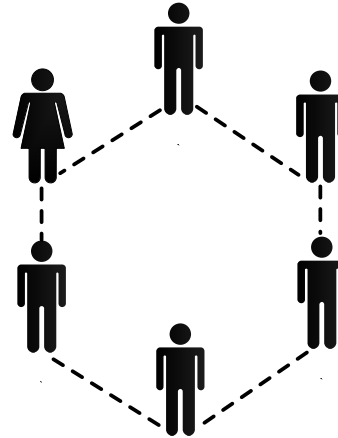


Figure 4.5 Project Team –  $C_n H_n$

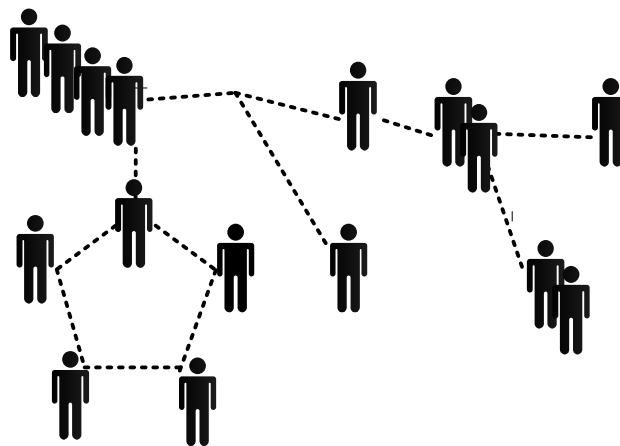


Figure 4.6 Cross-functional team  $C_n H_n$

Such a hexagonal bond structure in Benzene makes it a very stable compound. Formation of a team could be perceived, like Benzene Ring, as having a lead human atom (Carbon) and other human atoms (Hydrogen) joining hands to share explicit and tacit knowledge through covalent bonds Figure 4.5. The difference between Benzene Ring and a cross-functional team is in the number of atoms since a team may have any number of human atoms in cross-functional team  $C_n H_n$  where  $n$  can be any number (Figure 4.6).

#### **4.3.4      *Atomic structure of MO***

Enterprises such as MO's can be modelled in the same way as atoms. In its center, the Nucleus (N) represents the lean corporate core. The nucleus is surrounded by a number of orbits/shells. The innermost orbit of MO's, strongly holds the wholly-owned assets (such as plants and machines etc in case of manufacturing) as resource (R), core capability skills (S) and business intelligence as data/information (I) at the closest proximity of the lean corporate core (N).

The lean corporate core as N not only provides the innovative cultural leadership to the manufacturing atom but also supports and nurtures the innovation culture throughout the MO's. This strong pervasive influence and leadership, like a positively charged N, exerts a strong force of attraction on to its various strategic business units (SBU) revolving around it in different orbits representing various dispersed locations the same way negatively charged electrons revolve round the nucleus in an atom (metaphorical analogy). The N in MO's is also responsible for the intense customer contact and relationship building that drives the mission of the lean corporate core. This analogy also fits with the role of the nucleus as the prime mover for the molecular organisation model.

The key point here is that the only living entity in MO's are the human atoms - whether in the nucleus as lean corporate core or as people in various SBU's at its various orbits/shells. Human roles in different MO's might change but the structure of the human atoms does not. One can therefore argue that human atoms are the only 'living' entity and the fundamental building blocks of any enterprise the way atoms are for matter irrespective of its various forms such as solids, liquids and gases. Hence the fundamental building blocks of MO's are human atoms – the only living and unique entity.

Technology provides vivid metaphors for this boundarylessness. Businesses are now moving away from a traditional mainframe and client-server world - the world of hierarchies and boundaries to 'peer-to-peer networks' - organically evolving human network of networks. There is no fixed centre, there is no hierarchy; there are evolving networks of interacting individual sphere of influence through cyberspace. Such networks compete with each other - they combine, reform, integrate, absorb and pass on their own capabilities to future permutations and combination of networks.

Under molecularised technology - technologies are structured as a network of light expert systems, autonomous but integrated, flexible and open.

#### **4.3.5      *Molecular supply Chain***

The concepts of business process reengineering advocate to disaggregating businesses into processes, and then reconstituting them. Information technology is now able to disaggregate information repositories and exchanges as well.

The web drives process transaction and integration costs toward zero. This facilitates outsourcing, which in turn fosters best-in-class specialisation. Businesses can be built out of components, like so many Lego toys. Therefore the business design isn't just modularised; it is set free from any particular corporate entity. Businesses now exist between corporations, not within them.

#### **4.3.6      *Molecular Feedback***

In any situation, trust is built over time, through numerous interactions between individuals, partners and collaborators (Hacker et al, 1999). However, in key customer-supplier relationships it is irresponsible to rest on the effects of time to build the level of trust. The interacting individuals must be willing to speed up the process by engaging the time, resources and skills needed to get to know each other. Because a relationship between two companies is primarily a relationship between their people, it is important to enlist the right stakeholders as owners/drivers for the future of the business partner relationship. For key customer-supplier relationships it is important to manage the dynamics both within and across partner organisations.

In a molecularised organisation structure, individuals interact with their respective sphere of influence in a collaborative environment where mutual respect and trust plays a crucial role providing opportunities for performance improvement through spontaneous and continuous feedback.

## 4.4 Model for Molecular Organization

Using molecular model for individual relationships, one can examine its application to MO's. Organisations are said to be "Molecularised" when the top management respects and delegates the non-strategic decisions to its employees, its partners, its clients and when the organisation's ergo-structure is molecular. In a molecular organisation (MO) added value has the priority over economies of scale and the info-structure is a network of light expert systems, autonomous but integrated, flexible and open.

An empowered organisation is one in which individuals have the knowledge, skill, desire, and opportunity to personally succeed in a way that leads to collective organisational success. MO is an empowered organisation where the position is recognised as a business unit, the position-holder an empowered employee who can function autonomously within the objectives and policy guidelines, and the supervisor an inspiring leader rather than a link in an authority-based chain of command. In a MO the products/services integrate both the advantages of mass production and those of customisation.

In the 21<sup>st</sup> century continued existence can no longer be considered as a prima facie evidence of success. If anything, it is increasingly a cause for concern that the company in question is not sufficiently open to the real networks of people and processes that create and drive businesses.

In a molecularised strategy the top management respects and delegates non-strategic decisions to its internal and external stakeholders through an organisation structure that is ergonomic in a molecular perspective.

An atom is the smallest particle in matter that still maintains its chemical identity. A single person is like an atom in the cyberspace ready to be attracted by an opportunity for further interactions. Human atoms can enter any value chain or network of networks under suitable conditions of market demand, technology and customer and so on. Under dynamic conditions human atoms combine, compete, separate, and move in and out of a network.

Therefore the molecular architecture should address the basics of an enterprise i.e. its people, tangible and intangible resources and information on real time basis targeted to accomplish a task most efficiently with the perceived quality requirements of its customers in mind. What that means is allocation of right resource to the right person having right skills on right time triggered by right information on real time basis. This is a prerequisite for all tasks whether accomplished individually or collectively as a team.

At the micro-level of business, the architecture depicts the equivalence of an anatomic level of structure and functionality of the individual enterprise and the eco-architecture of the business that addresses multiple enterprises as they interact with each other in a marketplace environment.

An enterprise comprises of mission, policy, strategy, rules, hardware, software, function, information, plants and machines, structure and so on. These elements are inanimate (non-living). The animate (living) entity in any enterprise is its people who control the enterprise's entire lifecycle. Thus an enterprise may be viewed as a composite of living and non-living entities. This composite is also the fundamental building block of any enterprise in the micro-architectural level like atoms and molecules are in the case of matter.

#### **4.4.1      *The 4D Manufacturing Model***

A traditional manufacturing business unit may be explained in terms of a simple production cycle as proposed in Fig.4.7.

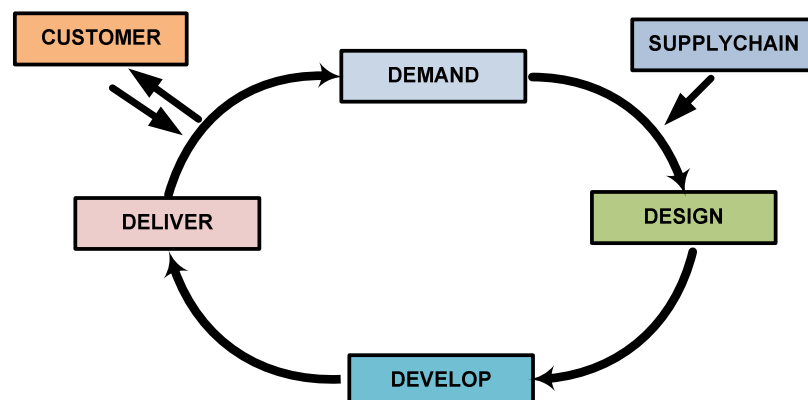


Figure 4.7 Synchronized Material and Information Flow

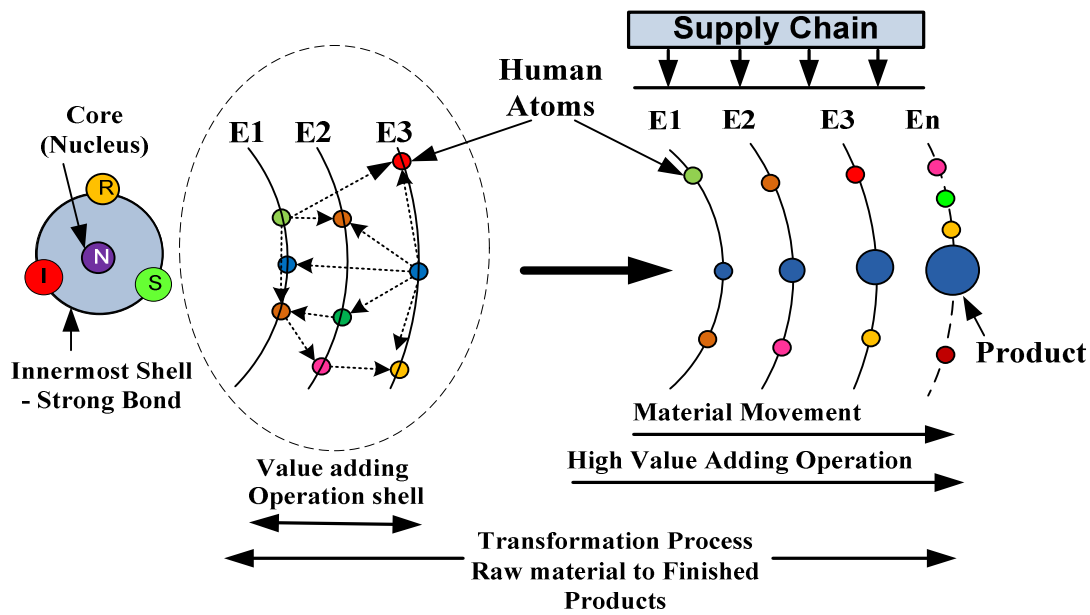


A supply chain is triggered by the ‘customer demand’ driven product life cycle management activities in a loop ‘demand-design-develop-deliver’ stages (4D). For simplicity reasons, planning, scheduling and shop floor management etc have been omitted in the proposed 4D-Model (‘demand-design-develop-deliver’). It is also assumed that the stage ‘Develop’ includes all manufacturing activities.

Human atoms (i.e. employees) can frequently change orbits/shells in the MO on priority basis either as an individual or in groups or as cross-functional teams. Human atoms move frequently and change orbits depending on where the new product or project is (priority). The orbital bands (a number of different orbits together) are where frequent movements of human atoms occur and most value adding activities take place. The key operational functions such as planning, scheduling, shop floor management and control etc are also performed by the human atoms in such bands. As the value adding operational activities mature towards completion, incremental but individual human energy is continuously spent by the human atoms to collectively and progressively transform raw materials to finished products.

Energy bands between energy levels  $E_1$  to  $E_3$  is the value adding band. Human atoms individually or in teams move around the band according to the priority (as communicated by either lean core nucleus or customer human atom) of the job or new project. The Supply chain feeds raw materials / parts etc in this band in synchronisation with the workflow. Gradually increasing size of the ‘black dot’ in different orbits denotes progressive value addition towards completion of the job. Thus raw materials get progressively transformed into products P as human atoms/teams spend energy to push the product towards the outermost shell having energy  $E_n$ . ( $E = E_1 + E_2 + E_3 + \dots + E_n$ ). Lastly when the manufacturing process is completed, product P becomes deliverable to the customer human atom that has a demand H. Thus a manufacturing type MO can be explained and visualised as in Figure 4.8.

Different human atoms are shown as ‘coloured circles’ in the value adding operation band for simplicity. They should be visualised as atoms with its nucleus at the center and R, S, I etc in its innermost shells as has been depicted. Gradual increasing size of the ‘blue circle’ denotes progressive completion of the product P to become deliverable to the customer human atom having demand H.



Legends:  
 N = Nucleus  
 S = Core capability skills  
 I = Business Intelligence (Data)  
 R = wholly-owned assets (Machines)

Figure 4.8 Movement of Human Atoms in Orbital Band (energy level  $E_1$ ,  $E_2$  etc)

The 'demand' from customer human atoms drives the 'design' and 'develop' activities by the producer/supplier human atoms either as individuals or members of cross functional teams and so on within the various value adding operation shells of the manufacturing centre concerned.

The supply chain feeds raw materials, parts and sub-assemblies etc to the required value adding shells/orbits or bands in synchronization (say Just-in-time etc). During the transformation processes from raw materials to the finished product, human atoms as individuals or members of the cross-functional teams push the product to the outermost orbit steadily by spending its total required energy  $E_n$  when the product is completed and becomes deliverable to the customer human atom. This completes the loop of the '4D' model. A double arrow in opposite direction implies that the manufacturing activities (by human producer atoms) begin and end with customer.

Thus the customer ‘demand’ drives ‘design’ and ‘develop’ activities in manufacturing that terminates with the ‘deliver’ phase of the 4D cycle and a customer order is said to be fulfilled and a transaction is completed ( $P=H$ ). Human atoms in fact constantly energise the 4D manufacturing model to make it look like a dynamic and living enterprise that is able to satisfy the ever-changing needs of customers in a far more complex and changing business environment. Hence this thesis holds the view that the human atom concept is embedded into the 4D manufacturing model.

#### 4.4.2 *Modelling Flow in manufacturing for Molecular Organization*

Figure 4.9 visualises the dynamic behaviour of the molecular organisation in a typical manufacturing assembly sequence. The lean core leadership nucleus (N) acts as ‘catalyst’ to influence the core capability process chain. It also influences the human atoms to change orbits frequently either as individuals, groups or as cross functional teams around a new project and/or prioritised job.

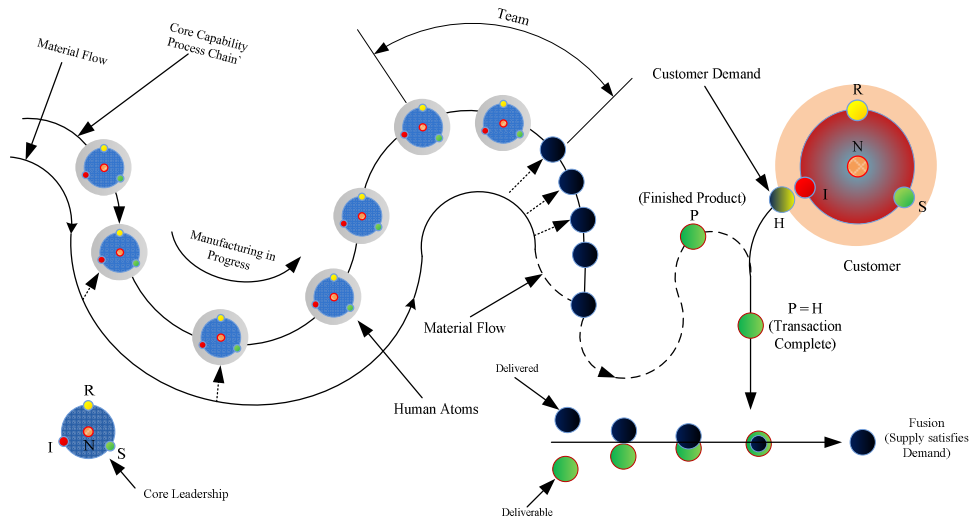


Figure 4.9 Material Flow Synchronized with Core Capability Process Chain

The synergy visualised, in the snapshot, here represents a MO that employs just-in-time (JIT) techniques. Material flow has been shown in parallel to the sinusoidal workflow to

emphasize synchronised material input just-in-time with the process chain. The supply chain members are autonomous and loosely - coupled units.

They are also MO's having lean core leadership at their nuclei. As the manufacturing process progresses from raw material towards finished products, the customer human atom (another molecular organisation) slowly aligns or vice versa, till the finished product is finally delivered.

Thus the 'delivered' product gets fused with the 'deliverable' as is the case in fusion between two atoms ( $P=H$ ).

#### **4.5 Using Molecular Model to examine GEW**

At any point of time, the global 'customer demand' drives the product life cycle management activities in a loop having 'demand-design develop-deliver' stages (4D) holds good for GEW China ([www.gewcorp.com](http://www.gewcorp.com)) as depicted in Figure 4.10.

As an OEM and ODM company, GEW exports mainly to Europe and North America and also delivers to the south East Asian and domestic markets in China. The deliveries are made either directly from the factory and/or through its strategic business hub in Hong Kong as the case may be. The consolidated customer demand from global, South East Asian and domestic market triggers the domestic and global supply chain. 'Design' and 'Develop' (including manufacturing) phases of the lifecycle management are carried out in Hong Kong and Dongguan factory respectively with close and regular consultation with the 'Brand' owner or parent company in Europe and North America. The global model for GEW China thus closely resembles to the 4D manufacturing model as proposed earlier in Figure 4.7.

The Dongguan factory is connected to a large number of loosely-coupled MO's as members to its supply chain and marketing channel comprising of traders, wholesalers, retailers and so on. The arrangements are purely based on trust, good relationships and pro-rata sharing of profits.

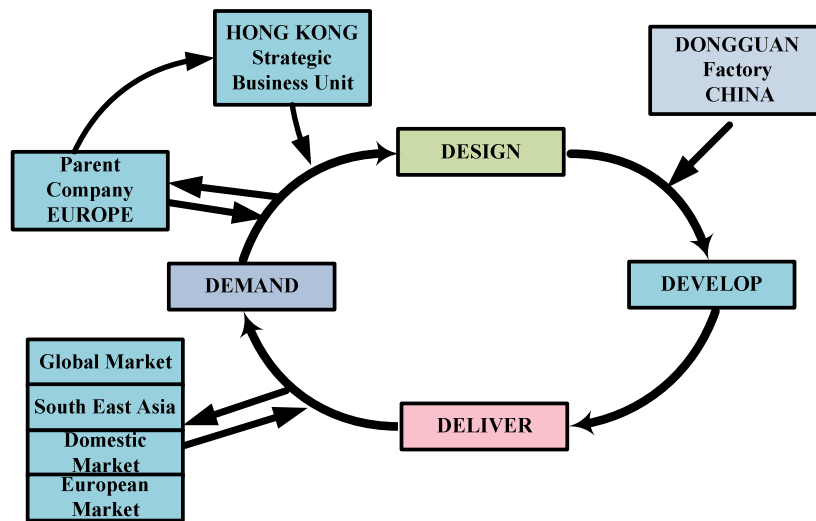


Figure 4.10 4D Global Model for GEW

The model for these operation units in China is explained by a micro-view representing individual factories or business departments in Figure 4.11. Various local MO's (as supply chain members) in China feed the assembly line at Dongguan factory with raw materials, parts and / or sub-assemblies just-in-time. The assembly line at the factory progressively builds the product  $P$  through various combinations of the outputs  $P_1 \dots P_n$  as supplied by the supply chain MO's in the region. This ensures seamless and timely delivery of finished products to its customers (MO's) through various channel members such as wholesalers, retailers and so on who are also MO's.

The key point here is that these tiny, autonomous MO's are loosely-coupled with the lean corporate cores of GEW, Hong Kong and the Dongguan factory. Headquartered with its lean corporate core in Hong Kong, GEW directly owns and controls its factory at Dongguan. The factory is well connected and supported by a large number of loosely-coupled supply chain members who are MO's by themselves. Various combinations of working arrangements exist between the factory and supply chain members depending on a need based strategy formulated by the corporate core (Hong Kong) from time to time.

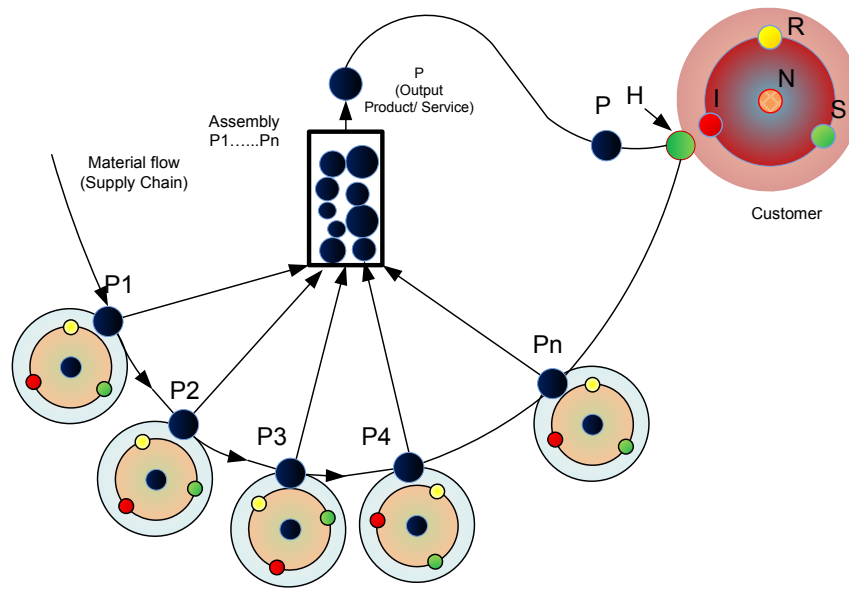


Figure 4.11 Modelling flow of individual units in China (Assembly Operation)

In similar working arrangements, the lean corporate core of the Parent company in Europe controls a number of other MO's, like GEW - Hong Kong, that are globally distributed. These tiny, loosely-coupled and globally distributed business units are also MO's that are supported by their respective array of local supply chain members (MO's) in the regions. In fact GEW is an MO by itself loosely held by its brand owners in Europe, North America or Japan etc.

It has been observed during the application case study at GEW, that the phenomena and analogical comparison between the dynamics of these MO's in terms of bonding and the role of human atoms (as supplier, customer and teams etc) are similar to inter-molecular reactions in chemical science. In the spirit of collaboration these MO's share resources, skills and shake hands brushing aside all contractual arrangements. They are also willing to get hooked 'on' or 'off' as needed by the lean corporate core. Complex business and transaction arrangements pose a demanding, highly dynamic and competitive business environment for MO's resulting in their increased volatility and high hook 'on' and 'of' turnover rate.

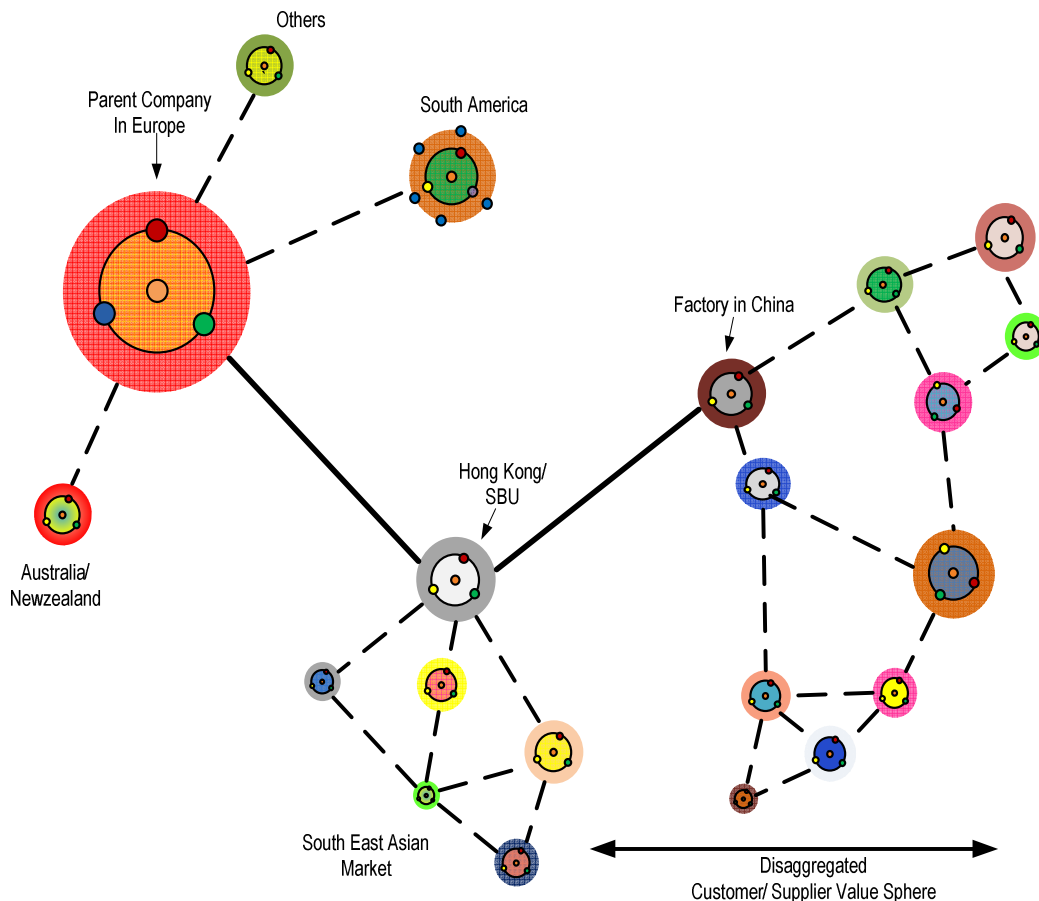


Figure 4.12 Application of MO's in the global model

The application case study also reveals that MO's have simple, flexible or almost no hierarchical structures at all since they could be entrepreneurs, small business owners, consultants and/or contractors and so on. A customer (MO) for one supplier (MO) could be a supplier (MO) to another customer (MO) and so on. MO's, therefore, exist and submerge in the heterogeneous mix of primary, secondary and tertiary manufacturer / dealer/supplier and customer relationship around a major cash flow. All MO's have their own lean core leadership as nuclei of atoms and human atoms (either as individuals or cross-functional teams) move frequently in different orbits according to the need or priority of a job or project Figure 4.12.

As a result, the identity of supplier and/or customer is blurred. The ultimate consumer knows only the 'brand' without traceability of the product ownership. They are submerged under the complex supplier-customer cluster of different sizes scattered all over. Hence, the methodology adopting analogical comparison of the concept of atoms, molecules, bonding

and molecular interactions of chemical science to model the molecular organisation works successfully for manufacturing in both factory and the extended global levels. Contextualisation of the modelling concept using various artifacts and constructs, as proposed in this dissertation, are also able to explain the basic structural and operational properties of MO's and how they interact. This could also possibly remove some operational problems involving human atoms as supplier, customer, individuals and/or teams thereby likely to improve overall efficiency. The proposed 4D generic model and the modelling flow helps also to visualise the dynamics of MO's.

## **4.6 Chapter Summary**

The shortcomings of the already established molecular theory lie in its inability to address the design aspects of enterprise architectures that are fundamental to achieve cohesion in the organization by improving management efficiency. This chapter has applied the established principles of chemical science to create a generic enterprise model for the upcoming trends for the molecular organizations (MO's) of the 21<sup>st</sup> century. An analogy is drawn between chemical and management science and introduced a brief concept of enterprise modelling. This concept is found most suitable for emerging enterprises with global network such as GEW.



## Chapter 5      Kaizen – Lean Six Sigma Model (KLSSM)

### 5.1 Introduction

The core essence of both PCM and MM, as discussed in the previous chapters, is people who may be perceived as separate living enterprises within an enterprise that interact among themselves and with others in another enterprise.

A business is a synchronised, orchestrated and time driven complex network of processes designed to achieve and aligned to accomplish the vision and mission of the enterprise. An enterprise needs to improve, adapt, transform, innovate and reengineer its business processes to meet ever-changing customer expectations and deliverables in an increasingly competitive global environment. To achieve this goal, an enterprise re-defines itself with its new visions, objectives and architecture. This will be done in a process as shown in Figure 5.1.

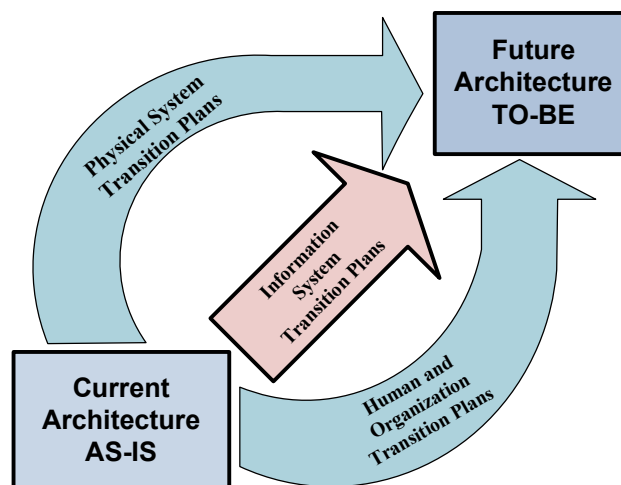


Figure 5.1 Enterprise Architecture Transition to the future

In the PCM strategy drives the EA which in turn drives people's roles and functions in different layers of operations. Activities in each layer are energised by respective skills (S) of people, available resources (R) both tangible and intangible on real time information (I). Output of the layered EA is connected to the customers who in turn are connected to

strategy via feedback layer in a closed-loop system. Customer needs are varied and always changing on the face of the fierce completion. For customer retention, enterprises in the 21<sup>st</sup> century need to be more vigilant and committed to the voice of the customer (VOC).

There are two types of business models one the transaction-driven business model and the other is relationship-driven business model. Either model is a valid one and gives a certain edge the other side cannot offer, but one has to choose the appropriate model since it alters the way one does business, the way price is determined and the way one delivers the products or services to its customer. The transaction driven business has the ability to act and grow or fail fast, whereas the relationship-driven business is a slower animal that needs to develop for a while before one can reap the benefits. Price is more flexible in the relationship-driven market where a premium price will be accepted, versus the constant pressure to lower prices in the convenience and transaction-driven markets. In a transaction driven enterprise various entities are interrelated and interdependent including both upstream and downstream channel members in the supply chain. The MM supports the transactional nature of the various entities at the micro-architectural level and is pivoted on the PCM.

Customer satisfaction is largely driven by quality product with service, timely delivery and justifiable cost. That is why Continuous Improvement (CI) as a philosophy is so crucial for the organizations today. The process of continuous improvement, driven by the changing customer needs, requires a new EA that PCM and MM cannot provide. The new EA has to fit well with the contemporary trend in sustainable manufacturing for wastage minimisation and recycling. This thesis argues that modern enterprises need a hybrid business model comprising of both the transaction-driven and the relationship-driven business models. That is why another new EA is required to overcome the shortcomings of the EA's in both PCM and MM.

Everything that people do is a process, whether it is documented or not, each area or function of an organisation is a composite of many processes and their interactions. In this process, both the understanding and the path for improvement constitute the lifeblood of total quality organisations. The transition process comprises of three transition plans i.e. physical system transition, information system transition and people transition. These plans

are the steps by which people add value, and it should be the aim of customer focused organisations.

In a recent case study on Ford Australia, it was found that defining present and future enterprise architectures for the purpose of transforming the enterprise in an improvement cycle is not sufficient to produce the desirable outcomes. The research showed that in addition to using EA as the basis for defining the changes, six sigma methodologies was used as the tool to facilitate progressive and continual enterprise model transformation to allow businesses to adapt to meet increased customer expectation and global competition. The philosophy of continuous improvement (CI) played an important in this case, ensuring a smooth transition between states of the enterprise.

As discussed in Section 2.8, CI tools are not restricted to ‘six sigma’ alone.

<b>Methodology</b>	<b>No. of Plants in Use</b>	<b>Plants (%) Plants (%)</b>
<b>Agile manufacturing</b>	41	4.6
<b>Lean manufacturing</b>	316	35.7
<b>Six Sigma</b>	29	3.3
<b>Lean and Six Sigma</b>	68	7.7
<b>Theory of constraints (TOC)</b>	43	4.9
<b>Total Quality Management (TQM)</b>	126	14.1
<b>Toyota production system (TPS)</b>	12	1.4
<b>No methodology</b>	186	21
<b>TOTAL</b>	<b>884</b>	<b>100</b>

Table 5.1 Popularity of various CI tools  
(Taninecz, 2004)

These established CI methodologies are currently used in manufacturing plants to achieve five key strategic objectives - cost, flexibility, speed, dependability and quality by improving overall performance (Table 5.1). However tools have not been applied in conjunction with enterprise modeling and hence efforts are piecemeal. It is therefore necessary to encompass Kaizen, Lean and Six Sigma Methodologies together since deployment of the appropriate, need based and cost effective hybrid methodology is very important for an enterprise to enjoy the benefits of integration and avoiding duplication.

## **5.2 Modelling considerations and views**

Literature review (Section 2.8) reveals that a well-structured and executed business process with CI initiative requires an integrated approach to derive benefits from all the tools (e.g., Kaizen, TPS, Lean or Six Sigma) while avoiding any duplication of efforts and resources since selective deployment of people skills and optimal resources creates a rapid and winning strategy. This notion further supported by a recent case study with Ford Australia (Vella et al, 2009) triggered the need to develop an integrated approach for the three of the most popular CI-tools (Kaizen, Lean and Six Sigma). This leads to consideration of the following imperatives prior to modelling:

### **5.2.1 *People***

When researchers and industry practitioners talk about improved performance, enhanced capability, competitive advantage and value creation etc and so on in the workplace they refer and really mean operational aspects of the business which must be led and driven by human in order to cascade down the benefits further down to the processes. People within the enterprise must be able to understand and keep track on the array of changing forces in the external business environment and translate these into collaborative, coordinated solutions. This requires a commonsense concept – a framework and a common language of strategy for change that would enable people to communicate with each other within the enterprise.

Responsiveness, adaptability and imagination are essential ingredients of an organisation for survival in the dynamic business environment today. These ingredients can be matched only by: it's People. People are the most important and crucial part of a manufacturing system (business) comprising of a set of machines, logistics, inventory, computers and so on.

### **5.2.2 *Process***

Business processes are driven and energised by people. Understanding processes is vital so that they can be improved by means of a systematic approach from a simple kit of tools or techniques. Whilst the individual approaches share common features and sometimes claim to include each other, there is no generally accepted or coherent map/topology of these

initiatives or of the selection criterion for an organisation to choose between them or structure an individual approach. One of the initial steps to understand or improve a process is by gathering information by which one can construct a “dynamic” model - a picture of the activities that take place in a process. Process maps precisely do that and are useful communication tools that help improvement teams to understand the process and identify opportunities for improvement. They provide a dynamic view of how an organisation can deliver enhanced business value and “What if” scenarios are quickly developed by comparing the maps of the process “As is” with the process “To be”.

### **5.2.3      *Strategy***

Corporate management (people) of the organisation is responsible for translating the aspirations and expectations of the shareholders (people) to the operational people in the shop floor. They are also expected to provide an innovative leadership in formulating the strategy, policy, rules and goals and so on through a consultative process. The task of putting the right strategy in place in right time is not only enormous but crucial too. Earmarking right individuals with appropriate roles and functions, rising above all organisational politics, and equipping them with right resources and support is not always easy. Strategy should therefore ensure that right resources are allocated to right people with right information in right time. While deploying or piloting new initiatives, resources should not be wasted in duplicating an effort or in reinventing an already existing array of CI tools. It is needless to mention that both time and resources are ‘scarce’ and therefore should be deployed smartly.

### **5.2.4      *Lean Six Sigma***

Lean is a systematic approach of identifying and eliminating non-value-added activities (Eliminate Waste) through continuous improvement (CI). Lean is a unified, comprehensive set of philosophies, rules, guidelines, tools and techniques for eliminating ‘muda’, the Japanese word for waste. The concept and initial deployments of lean manufacturing originally came from the Toyota Motor Car Company (Womack et al, 1991). The key principles of lean include:

- Voice of the customer

- Value-stream or process mapping
- Continuous improvement
- Elimination of waste everywhere,

Lean defines 7 types of waste

- Overproduction – Producing more than the customer needs right now
- Transportation – Movement of product that does not add value
- Motion – Movement of people that does not add value
- Waiting – Idle time created when material, information, people, or equipment is not ready
- Processing – Effort that adds no value from the customer's viewpoint
- Inventory – More materials, parts, or products on hand than the customer needs right now
- Defects – Work that contains errors, rework, mistakes or lacks something necessary

This requires locating the waste first to eliminate or in other words exposing the waste.

In an aftermath of globalisation and instant access to information, both products and services have changed the way customers conduct business – old traditional business models no longer work. Six Sigma has become a part of business culture today (Harry 2000). To achieve Six Sigma quality, a process must produce no more than 3.4 defects per million opportunities. An “opportunity” in this context is defined as a chance for non-conformance, or not meeting the required specifications. This calls for nearly flawless execution of key business processes. DMAIC sequence is the heart of the Lean Six Sigma methodology.

When Lean is added to Six Sigma, slow processes are challenged and replaced with more streamlined workflows. Additionally, the data gathered during Lean Flow implementation helps identify the highest impact Six Sigma opportunities. When Six Sigma is added to Lean, a much-needed structure is provided that makes it easier to consistently and predictably achieve optimum flow. The two methodologies work so well together, that a new, integrated, Lean Six Sigma approach, with its own unique characteristics, has been defined and incorporated by several leading organizations, including Xerox Corporation.

Lean Six Sigma is the application of lean techniques to increase speed and reduce waste, while employing Six Sigma processes to improve quality and focus on the Voice of the Customer. Lean Six Sigma means doing things right the first time, only doing the things that generate value, and doing it all quickly and efficiently.

Latest trend in Lean Six Sigma is built on the knowledge, methods and tools derived from decades of operational improvement research and implementation (Figure 5.2). Lean approaches focus on reducing cost through process optimization. Six Sigma is about meeting customer requirements and stakeholder expectations, and improving quality by measuring and eliminating defects. The Lean Six Sigma approach draws on the philosophies, principles and tools of both.

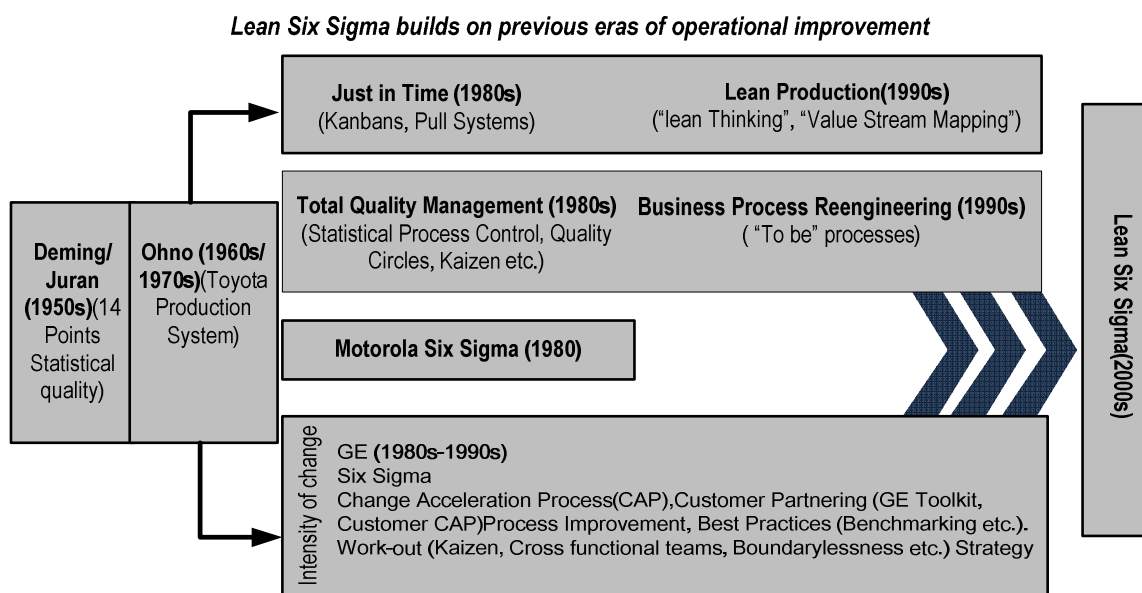


Figure 5.2 Lean Six Sigma

A key concept in lean is Kaizen. Kaizen means, breaking apart the current situation, analysing it, and quickly putting it together to make it better (Masaaki 1986). Kaizen process begins with a review of the baseline data to identify opportunities and select a target area. Without it, all improvement efforts using Kaizen to eliminate waste (muda) are not sustainable and will slide back to the original position before Kaizen. Wedge to stop this

from happening is to standardise the work through SOP (Standardised Operating Procedure) Figure 5.3.

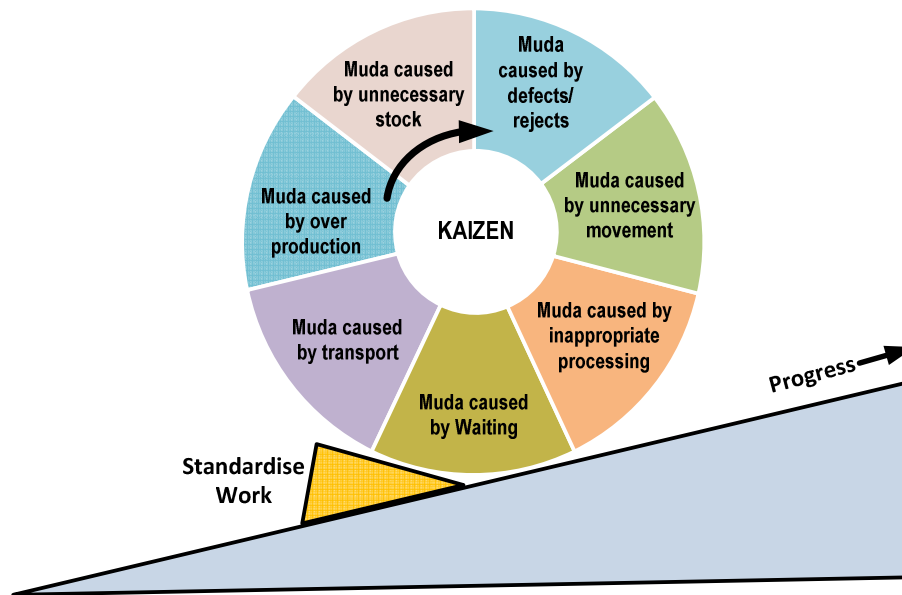


Figure 5.3 SOP used to prevent degradation of the process

If a company has a combined system of Six Sigma, a strict adherence to established processes, and local resources who are constantly looking for ways to make their processes better (Kaizen), the situation becomes the best. This puts the organisation in a better financial position in the long-run because improvements happen on an ongoing basis in addition to the occasional breakthrough. This concept has been investigated in Section 2.8.

### 5.2.5 Automation

CI efforts are mostly conceived, led and implemented by people where analytical skills are important. People will change after a while. To sustain an improved process, the normal method is to install the new process as a standard. The term automation is used to express standardised and repetitive processes subject to cost/benefit leverage. Since unnecessary automation can lead to additional inflexibility of the system at increased cost or cover up an inherent flawed process.



Cars are increasingly complex and software-dependent. Recent problems with Toyota that required software fixes, not mechanical ones, have raised important questions over the increasing electronic content of modern vehicles. What these cases highlight is the increasing electronification of the car. Legislators and the motor industry alike have automatically assumed that increasing the electronic content of cars is a good thing, pointing to the appearance of safety regulations that will mandate Advanced Driver Assistance Systems (ADAS) such as electronic lane departure warning (LDW) and advanced emergency braking (AEB) technologies. Whilst electronics has increased efficiency and passenger comfort, it has also exposed the consumers to higher risk of accidents and manufacturers to painful recalls. It has also caused an inordinate blow to consumer trust and could yet lead to a slowdown in the electronification of the automobile (Wheatley, 2010).

Engineering organisations benefit the most from Six Sigma. This is because these types of organisations are high technology, high professionalism, and are operating in an expensive error environment in which “automation” of the improved process will reduce the chance of making the same type of errors again. Alternately, in more manual type of enterprises such as in a typical service organization, lean methodology would be used more to allow for flexibility in the process to deal with abnormality.

### **5.2.6      *Customer***

An organisation needs to focus on the customer, both current and potential, for its CI activities to improve the functions that have a real impact on the customer perception. Being fast, flexible and efficient in these areas can make the difference. It needs to focus on creating value for its customers and delight them with the experience of doing business with them.

For any business, it is customers that drive the success or failure of the enterprise. That's where the focus of CI efforts must be (Setijono and Dahlgaard, 2007). There are multiple places in any organisation where improvements can be made to solve its customers' problems, and most of these are not on the manufacturing floor. Whether it is reducing the response time on new product development or quote requests, customising products to exactly what customers need to solve their problems, reducing delivery lead time or ensuring that products and services are defect-free from the customer's perspective, an

organisation's CI efforts need to be focused on what its customer requires, not its own perception of what is needed.

In the current economic environment, very few companies are seeing revenue growth from their existing customer base, so new customers are needed to stabilise and increase revenues. A focus on the customer's needs and using CI efforts to increase customer value will help an organisation to attract these new revenue sources. Any marketing/sales department is aware, it is often not the product that is critical to attracting new customers but it is the speed and flexibility of the organisation in providing the solution to the problem those results in closing the sale with a new customer. If an organisation can deliver customer-specific solutions faster than the competition, that is often more important than price in closing the sale. That is where one's CI efforts should be focused on.

#### **5.2.7      *Information Flow and Feedback***

Information is important in any enterprise involved in continuous improvement and lean transformation. When one looks at flow it is not just about the materials in the manufacturing operation; it is also the flow of information through the support functions of the business. The flow of both information and materials is critical to reducing the time elapsed in the cash-to-cash cycle for the business. This time period from when one pays the expenses and materials related to an order until collection on the invoice for the products produced is called the cash-to-cash cycle and is an indication of the amount of cash tied up in the business. Minimising the amount of cash invested in the business can make the difference between survival and bankruptcy in the current economy.

In many organisations, the time consumed in the information flow, both pre-and post-production, can be longer than the material flow time through production and is also a cash drain on the business (Silva et al, 2009). When one goes through the process and produces a current state (AS-IS) value stream map, any accumulated paperwork or materials is an indication of a delay that increases the time lapse in the cash-to-cash cycle and increases the amount of cash invested.

Irrespective of whether a business is a make-to-order or make-to-stock operation inventory accumulations in both information flow and material flow consumes cash since interruptions

to both information and material flow increase the elapsed time and the amount of cash invested in the business

Most companies understand the value of customer feedback and they collect it for good reasons. These companies realise that how their customers perceive and feel about them, based on their experiences that can and does impact their business. Customers have choices of whom to do business with, so if their experiences and perceptions are not positive, they will go elsewhere.

One of the reasons much customer feedback is not acted upon is that the process of making it actionable is often unnecessarily complicated and not affordable. Transforming feedback into something useful for decision making is sometime laborious and cumbersome. Moreover actions on feedback can only occur after decisions occur. Sometimes the feedback process itself is biased against action. As a result customer feedback is often viewed just as interesting data that is theoretically useful, but often too costly to collate, interpret and link to the respective business process.

Customer (and employee) feedback provides the foundation upon which successful companies are built. It delivers strategic guidance and actionable insights that enable companies to improve marketing and customer service, to deliver better customer experiences, to develop and refine their products and services over time, and to profitably grow the business. That is why a closed loop feedback system connecting customer, strategy and enterprise architecture is so important.

### **5.3 Modelling Approach**

According to GERAM, an enterprise goes through various lifecycles. Generic Enterprise Reference Architecture (GERA) as depicted in Figure 5.4 defines the enterprise related generic concepts recommended for use in enterprise integration projects. These concepts include lifecycle; enterprise entity types, enterprise modelling with business process modelling; integrated model representation in different model views and modelling languages for different users of the enterprise architecture (business users, system designers, IT modelling specialists, among others). It recognises that within the enterprise's lifecycle, there are many phases. Hence, multiple activities are occurring within the lifecycle.

In particular, CI projects would be active after the enterprise is implemented as shown in Figure 5.5.

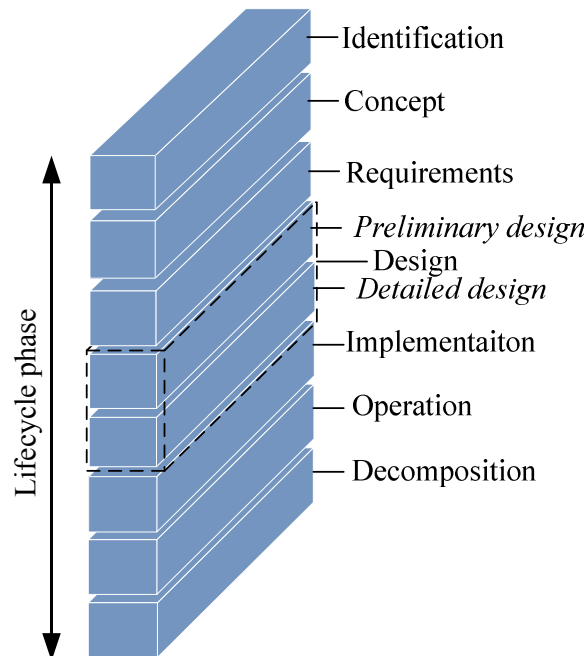


Figure 5.2 GERA Life-cycle phases for any enterprise  
(IFIP-IFAC Task Force, 1999)

The main focus of any CI initiatives including Kaizen - Lean Six Sigma is in the Operation phase. In order to respond to ever changing customer expectations enterprise needs a flexible, expandable, agile and adaptable architecture. The objective of such an EA in the operation phase is to:

- Establish baseline performance level
- Develop Future State Concept maps
- Implement elements to create complete system in Value Stream
- Learn to manage system
- Learn to improve system and results
- Continuously refocus and improve again

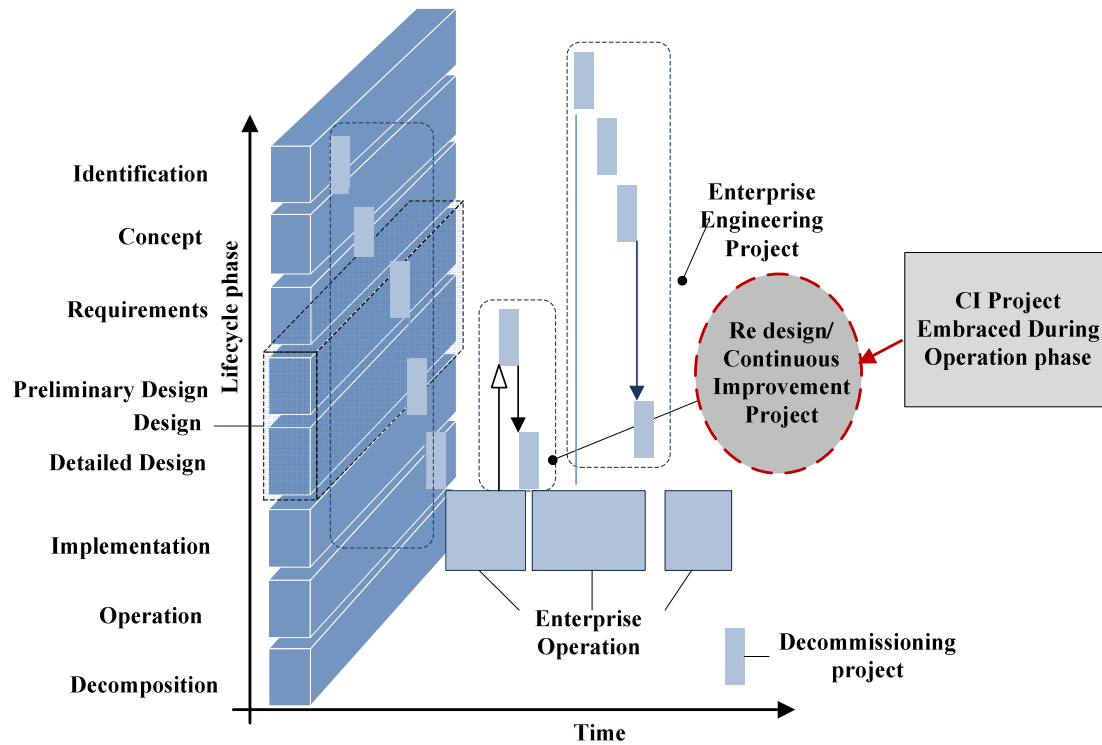


Figure 5.3 Continuous Improvement (CI) projects in operation phase  
(Adapted from: IFIP-IFAC Task Force, 1999)

The success of the new (future) enterprise depends on the “correctness” of the enterprise vision and its well managed implementation. The continuous process improvement (CPI) is therefore always risky and is generally non-responsive to external environment.

There is no systematic study on how an enterprise should embrace CI to achieve a less risky but progressive path. A new approach is required to assist enterprises not only to define their enterprise models, but also to re-engineer their processes and structures in a predictable way.

### 5.3.1 *Architecture Framework for Continuous Improvement*

Architecture is defined as a clear representation of a conceptual framework of components and their relationships at a point in time. A discussion of architecture must take into account different levels of architecture. These levels can be illustrated by a pyramid, with the

business unit at the top and the delivery system at the base (Fong and Goldfine, 1989). An enterprise is composed of one or more Business Units that are responsible for a specific business area. The customised levels of architecture are separate yet interrelated. An enterprise architecture reflects an awareness that the levels are logically connected and that a depiction at one level assumes or dictates that architectures at the higher level.

The architecture framework for CI is customised as a four layered architecture based on the foundation support of six sigma training, mentoring and certification (Belts – Green, Yellow and Black). Voice of the customer (VOC) drives the strategic diagnostic analysis layer of the architectural framework for continuous improvement which in turn drives the operational governance using metrics to pinpoint specific opportunities and ensures effective execution. In the execution layer trained belts in the organisation lead the DFSS (Design for Six Sigma) or DMADV (Define-Measure-Analyze-Design-Verify), DMAIC (Define-Measure-Analyse-Improve-Control), Lean, Kaizen and other IT enabled CI-Tool Box such as ERP, MRP, CRM and so on projects Figure 5.6.

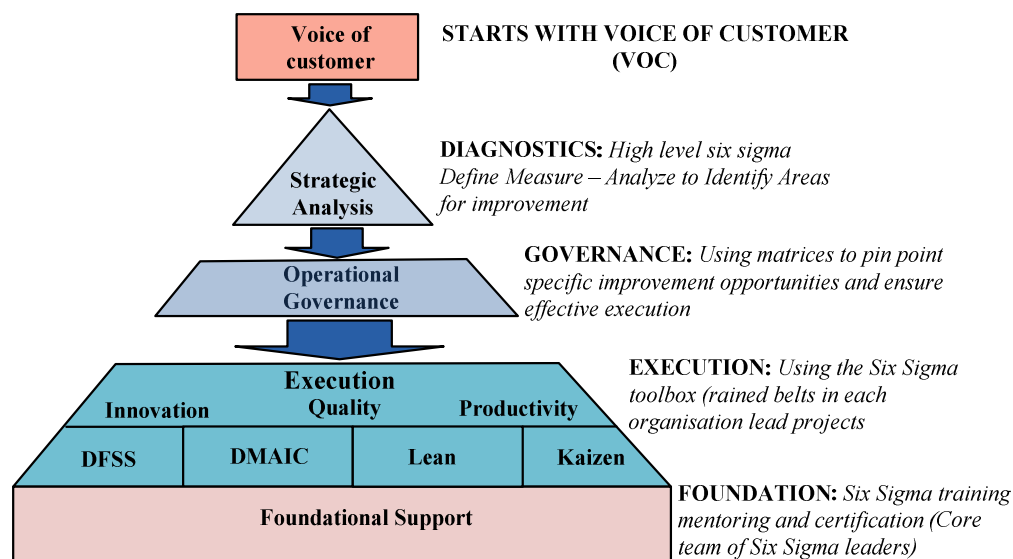


Figure 5.4 Architecture Frameworks for Continuous Improvement

### 5.3.1.1 Diagnostics

The Define phase of the DMAIC process is often skipped or short-changed, but is vital to the overall success of any Lean Six Sigma project. This is the phase where the current state,

problem statement, and desired future state are determined and documented via the Project Charter.

The Measure phase is where quantitative and qualitative data is gathered to get a clear view of the current state. This serves as a baseline to evaluate potential solutions and typically involves interviews with process owners, process mapping of the key business processes, and gathering data relating to current performance (time, volume, frequency, impact, etc.).

The Analyse Phase studies the information gathered in the Measure phase, pinpoints bottlenecks, and identifies improvement opportunities where non-value-added tasks can be removed. A business case is conducted which takes into account not only hard costs but also intangible benefits that can be gained, such as user productivity and satisfaction, to determine if the improvement is cost-effective and worthwhile. Finally, the Analyse Phase is when technological recommendations are provided.

#### ***5.3.1.2 Governance***

During the ‘Improve’ phase, the solution is piloted and plans are made for full scale implementation. The Improve phase is when recommended solutions are implemented. A project plan is developed and put into action, beginning with a pilot program and culminating in full-scale, enterprise-wide deployment. Where appropriate, new technology is implemented, workflows are streamlined, paper-based processes are eliminated, and consulting services are initiated. Key factors of success during this phase are acceptance by end users and enterprise-wide change without any degradation of current productivity levels.

#### ***5.3.1.3 Execution***

Once a solution is implemented, the next step is to place the necessary “controls” to assure improvements are maintained long-term. This involves monitoring and in many cases, publicising - the key process metrics to promote continuous improvement and to guard against regression.

A common practice is to put key metrics, including hard cost savings and achievement of pre-defined Service Level Agreements, in full view “on the dashboard” to provide

continuous feedback to the organization and so decision-makers can assess the project's level of success as it moves forward.

#### **5.3.1.4 Foundation**

Effective execution (Control) is ensured by deploying the certified core team of Six Sigma leaders as foundation. This foundation training program outlines the key principles and practices inherent in Lean Six Sigma. It is an ideal introduction for those new to this methodology, or for those keen to consolidate their training and knowledge in this area.

By incorporating this practical hands-on improvement project, participants are able to learn how to deliver and manage organisational improvement in a realistic way. Theory is important, but the real test lies in the ability to put this knowledge into practice.

The training program can be used as a foundational learning experience for all staff in an organisation. It may be particularly useful for those involved in improvement projects or improvement initiatives.

#### **5.3.2 People-Centric Architecture Framework**

Quality Function Deployment (QFD) is a flexible group decision making tool that offers an effective means of communication, information transformation and resource allocation. The QFD graphical display is called the "House of Quality (HOQ)" because of its shape and provides a framework that guides the team through the QFD process. The HOQ serves as a conceptual map that provides the means for inter-functional planning and communication. It contains information about the customer values, mechanisms to address these values in the product and criteria for deciding which of the mechanisms will provide the greatest customer satisfaction. It is basically a "Mapping" technique throughout a system-development process that involves surveys, reviews, relationship matrices all centered on the theme of translating the "Voice of Customer" into items that are measurable, actionable and potentially capable of improvement (Khawaja and Benjamin, 1996).

People are the key in relation to rapid change (and a barrier). Enterprise Architecture is about people. People always focus on projects but the steady state should be the focus. The



EA is a continuous improvement model by itself. If the organisation gets a coherent view then the management and the employees eventually do better decisions. What is missing from EA frameworks is a focus on an integrated view of people with the key components of the enterprise and a way to align them with customer, business needs and strategy. Traditional EAs are based on top down approach driven by its mission, vision and policy and so on where the pervasive role of people is not properly reflected. Any EA is meaningless and static if is devoid of people. If people are not involved prior to and during any fundamental change process they get upset, lose the sense of belongingness with the enterprise. This creates apathy and brews resistance. This is all the way more true especially in any continuous improvement (CI) effort.

CI thinking does not start, or end, with the production process. It requires a fundamental change from discrete departments guarding their own empires, roles, ideas, information and direct reports to a new form of ‘collaborative’ organisation. Communication barriers have to be broken down and information made visible, transparent and easily available. This requires a shift towards a process view with cross functional teams dedicated to problem solving and driving out waste to enhance value and optimise the value stream.

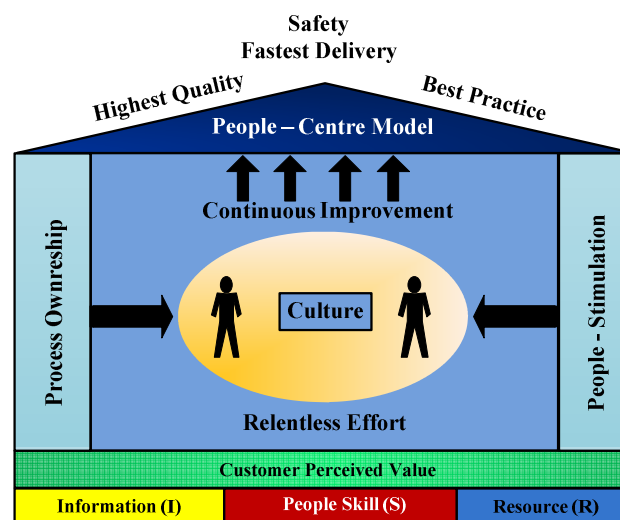


Figure 5.5 People Centric Architecture Framework

The leadership needs to be devolved and dispersed in groups and teams identifying the responsibility for ‘how’ objectives would be met and ‘who’ would be responsible for achieving them as was enumerated in the MM. This calls for a people-centric, people-driven

and people-led philosophy and policy - enterprise wide. Right from the inception of CI - project selection to deployment, a congenial cultural environment needs to be nurtured within the organisation as shown in Figure 5.7.

Inspired and stimulated individuals in the workforce should focus their relentless effort on Customer perceived value - a compass to ensure deliverables. An inspired workforce with onus in process ownership forms the two pillars of the people-centric architectural framework. The foundation of the framework is built upon the micro-outputs of individuals in the workforce. A people-centric and compassionate organisation culture holds the core of the framework. The roof of the framework is tiled with highest quality objectives and best price joined together at the ‘safety and fastest delivery first’ edge. People spend energy in their relentless effort to bring dynamism into the enterprise. In today’s complex business environment people need appropriate tools to help them think strategically and to coordinate the changes they themselves will need to implement. This framework forms the basis for such an endeavour.

### 5.3.3 *People-Centric Architecture Framework for Continuous Improvement*

This framework embeds the Architectural Framework for Continuous Improvement into the People-Centric Architectural Framework with skills (S), both tangible and intangible

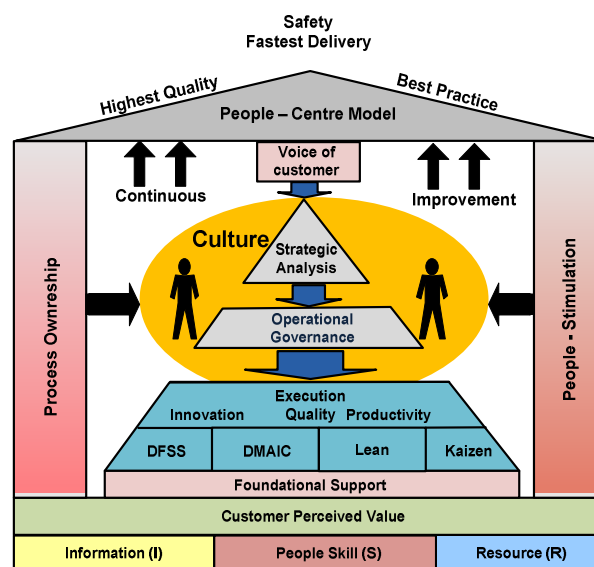


Figure 5.6 People-Centric Architecture Frameworks for Continuous Improvement

resource (R) and real time information (I) as the common foundation since people's skills, resources and information is the key driver for enterprise transformation and change (Figure 5.8). Pervasive presence of people in the shop floor makes an enterprise living. May it be innovation, quality or productivity people are the prime movers and the life blood for continuous improvement.

That is why both the frameworks can be embedded to each other with S, R and I as the fundamental and common entities at the micro-architectural level.

#### **5.4 Kaizen – Lean Six Sigma Model (KLSSM)**

The literature review revealed that conventional EA's with different layers are often represented as a pyramid like structure (Figure 5.6) whereas the QFD graphical display called as "House of Quality (HOQ) with two slanted roofs (Figure 5.7) is held high by continuous improvement methods by people of the People-Centric Model (PCM) as discussed in Chapter 3. Therefore the EA had to be impregnated into the QFD to develop the People-Centric Architecture Framework (Figure 5.8) above. The foundation of this framework rests upon people skills, resource and information common to PCM. This research has created the KLSSM based on the modelling flow as described above where its EA is embedded into the house of quality which in turn is dovetailed with the PCM.

The core essence of the KLSSM is change and enterprise transformation through continuous improvement and innovation with people in the forefront. The model is pivoted on the people skills (S) flanked with resource (R) and information (I) on either side. The model has a layered flexible EA with built-in lifecycle phases. The layered architecture embeds the unified CI - tool box such as Kaizen, Lean Six Sigma and so on. Depending on the need or choices made the tool box can be further enriched and enhanced with other IT enabled CI tools like ERP, MRP, SCM, CRM and MES and so on.

The pair of black vertical dotted lines signify the flexibility for additional tools and/or further enhancement where as the yellow vertical dotted lines imply that S, R and I has a pervasive role in the people-centric model including the closed feedback loop with the Customer. The KLSSM is customer facing and is driven by the strategy formulated by

ongoing brainstorming and collaborative overtures in an organisational culture of trust and mutual respect as shown in Figure 5.9.

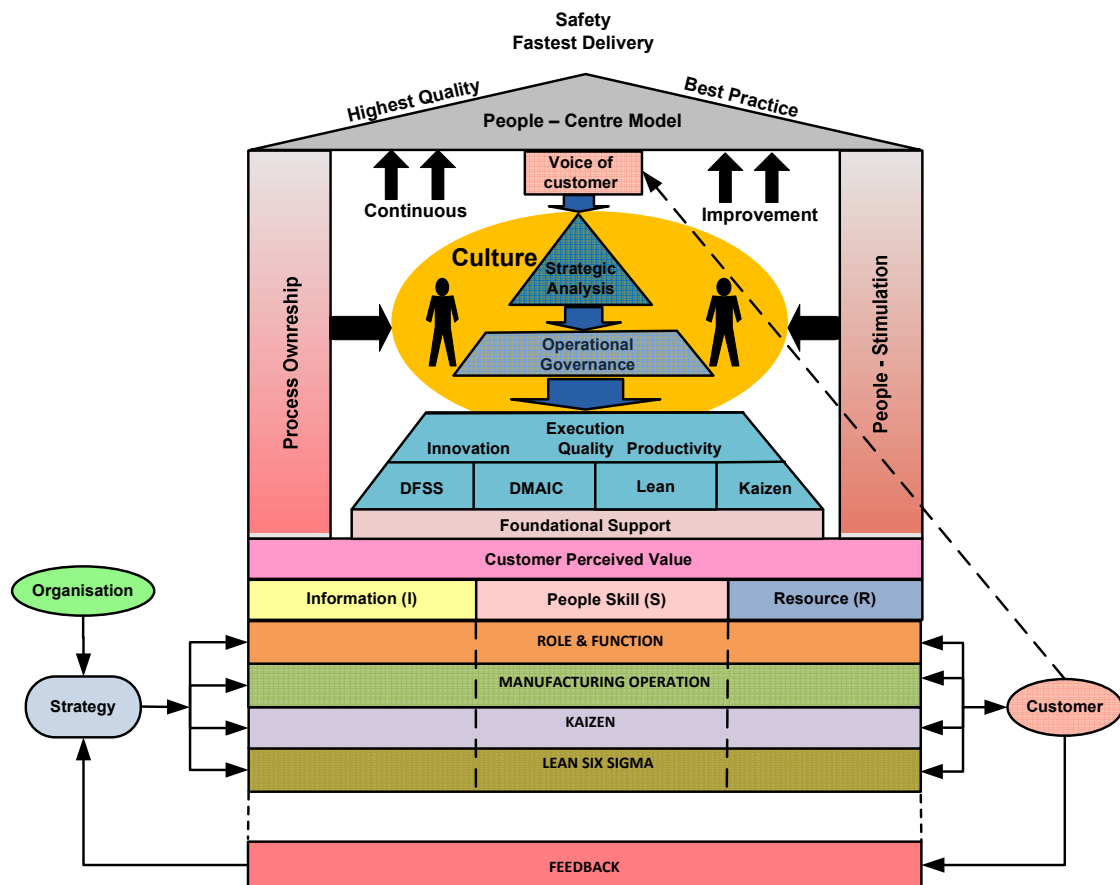


Figure 5.7 Kaizen – Lean Six Sigma Model (KLSSM)

However the lean core corporate is responsible for translating the aspirations and expectations of the shareholders to the operational people in the shop-floor. They are also required and expected to provide an innovative leadership in formulating the strategy, policy, rules and goals and so on through a consultative process. The strategy should also encompass earmarking of deserving individuals and then allocating them with appropriate roles and functions, rising above all organisational politics. Strategy should also ensure that right resources are allocated to those individuals and right information is channelled to the right people on right time.

## 5.5 Application of KLSSM to Mackay, Australia

The KLSSM has been used to model Mackay Consolidated Industries Pty Ltd, Australia ([www.mackayrubber.com.au](http://www.mackayrubber.com.au)). Mackay has grown to become a major supplier of a diverse range of engineered rubber and bonded metal/rubber composite products for the automotive, defense, transport, construction and industrial markets. Their products are exported worldwide. Their commitment to uncompromising standards of excellence in product development, material formulations and all facets of production, has resulted in the successful penetration of new markets and sustained profitable growth. Success in these chosen markets has been built on a simple philosophy – understanding customers’ needs and providing timely, cost effective engineered solutions. Their technical expertise, customer responsive service and commitment to continuous improvement, backed with sustained investment, have ensured that their reputation for reliable, high quality, innovative products will continue. Their Standard Operating Procedures (SOP) conform to the Quality Management System and is certified by NCS International (AS/NZS 9001: 2000). It is applicable to the entire product lifecycle management encompassing design and manufacture of rubber and rubber composite products, hoses, mouldings, extrusions, assemblies and fabrications ‘end to end’ of their substantially large product portfolio ([www.mackayrubber.com](http://www.mackayrubber.com)).

It has been observed that Mackay has a company-wide quality policy and are committed to satisfy their valued customers always. The Senior Management is very supportive and committed to embrace CI-philosophy at all levels of their operations ‘end to end’ in all its four SBU’s. As a strategy Mackay follows a four-prong principle – Conformance, Performance, Customer and its people. People play a pivotal role in Mackay.

When KLSSM is applied, it is observed that Lean Six Sigma is absent in the layered architecture at Mackay and it embeds hybrid version of Kaizen and Lean only instead (Fig.5.10).

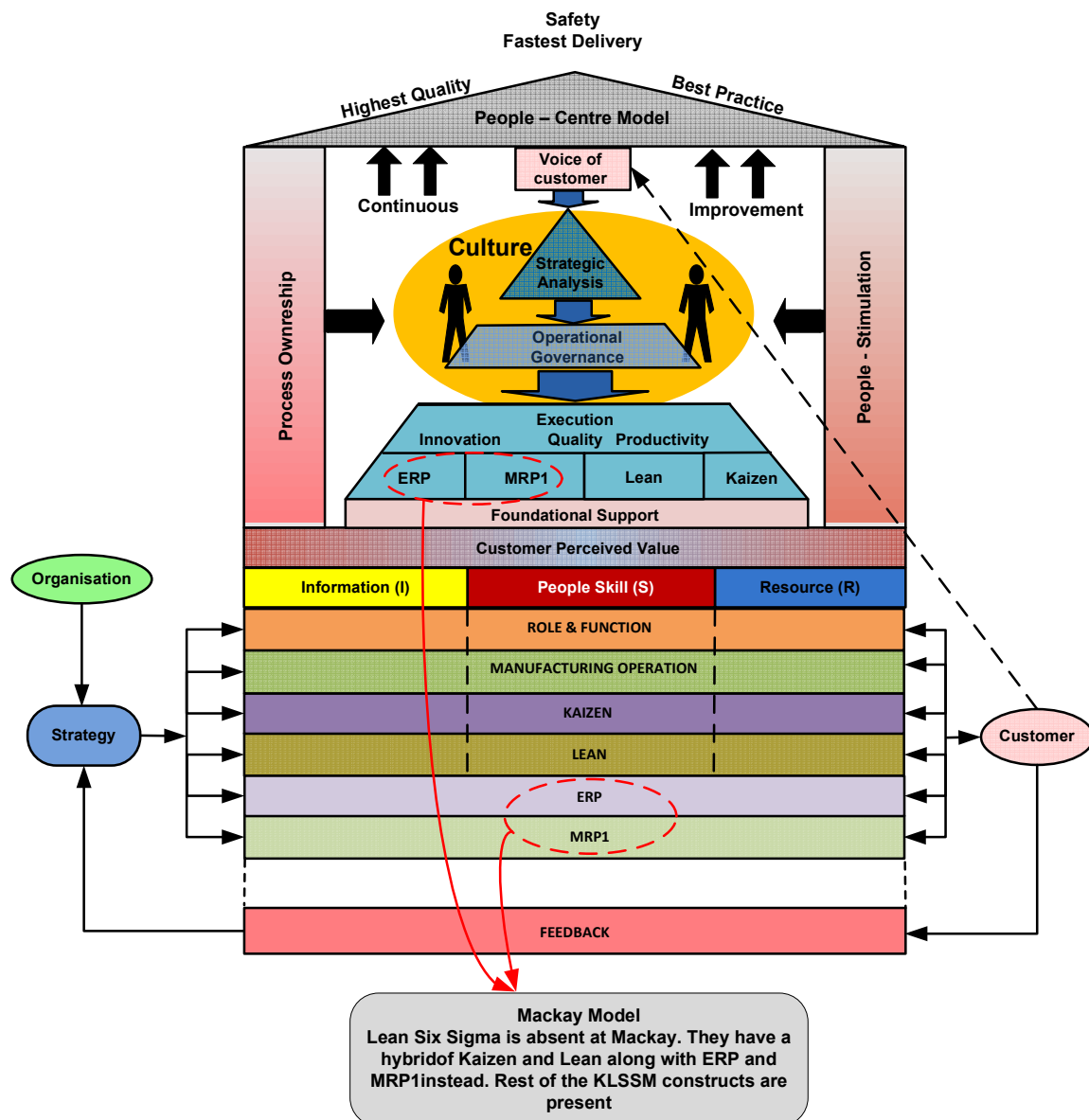


Figure 5.8 Modelling Flows at Mackay

During the discussion Mackay mentioned that they have future plans to introduce Lean Six Sigma. Therefore when the KLSSM was applied to Mackay, the other modelling constructs such as strategy, feedback and customer and people (R, S, I) fell in place. At the time of writing this dissertation quantitative data in support of benefits for this new model are not available.

## 5.6 Chapter Summary

Continuous Improvement (CI), as a philosophy, has already been tried out in the field and is therefore well proven. Improper selection of improvement projects/tools and their subsequent deployment can easily lead to corporate frustrations. People and process play the most crucial role in any CI efforts. However, the workforce is often confused amidst too many tools promoted by an ever-increasing number of vendors, consultants and so on.

In the complex business world today Continuous improvement (CI) has become an integral philosophy for critical survival in many organisations. Kaizen along with Lean and Six Sigma are the most popular CI-tools besides IT enabled ERP, SCM, CRM, MES and others. However careful selection and deployment of the right combination of tools are critical in the operation phase of the enterprise lifecycle of GERA. This chapter has first developed an architectural framework for KLSSM with people as its centre-piece. Based on this framework KLSSM is developed. Finally a case study has been discussed to demonstrate the modelling flow in KLSSM.

## **Chapter 6      Globally Dispersed Models (GDM)**

### **6.1 Introduction**

Manufacturing is an indispensable part of the economy and is central to the activity that encompasses product, process, resources and plant. Organisations of the 21<sup>st</sup> century need to embrace significant paradigm shift - a transition from competing on cost to competing on added value. The new paradigm requires high performances, customisation, new business models, new dimension of human endeavour and a service oriented culture in manufacturing.

In the era of mass-collaboration and ever increasingly complex, geographically dispersed and distributed manufacturing environment, the collaborating partners are facing a mammoth task to seamlessly integrate manufacturing operations. Non-availability of appropriate standards in interface design and security issues is haunting investors all around.

Large manufacturing firms are moving towards a geographically dispersed but globally integrated business model. There is also a growing emphasis on human-centered manufacturing and environment. Manufacturing firms are facing the challenges of ageing/emerging workforces with investment in organic knowledge and its management. Regulatory environmental drivers such as climate change, the depletion of natural resources and pollution caused by rampant industrial activity will shape the future of manufacturing.

As discussed in the literature review (Section 2.9 and 2.10) a manufacturing enterprise has to continuously evolve and transform like any other adaptive and complex entity. Intense global competition, climate change and sustainability are the key issues for the 21st century organisations and need to be addressed through collaborative and extended networks. Hence, architecture for manufacturing enterprise should shift from ‘human-centered’ approach towards ‘human-conscious approach’.

The Molecular Model (Chapter 4) was developed during the first study tour to the Hong Kong Polytechnic University when the opportunity arose to apply the model to GEW Corporation also headquartered in Hong Kong. During the field study at GEW it was



observed that although the Molecular Model could explain its organisation structure and transactional characteristics but fell short to portray the company's global outfit (Chattopadhyay et al, 2010d). This triggered the need for another new model that could address these shortcomings.

During further investigations and discussions with a number of local companies in Australia it was observed that Flowserve ([www.flowserve.com.au](http://www.flowserve.com.au)) had similar global operational features in their manufacturing outfit and accordingly a case study was subsequently undertaken at Flowserve.

Literature review shows that humans provide characteristics such as judgment, flexibility, adaptability, experience, and sentient knowledge (feel for the process) and are therefore essential traits for any manufacturing systems analysis irrespective of country and its geographic location (Section 2.9 and 2.10). In line with the *Manufuturing* and *Monodzukuri* spirits, manufacturing systems are moving toward distributed management nowadays because centralised management is susceptible to changes in demand and equipment conditions and the operational structure at Flowserve exactly fits into this.

Manufacturing companies today need to pursue variable (diversity of product offerings), variable-volume production to adapt to dynamic and fast changes in the quantity and models being produced. Today's business model design embraces a multi-disciplinary consultative approach requiring the corporate to advocate and promote awareness at all levels across the enterprise about its uses and benefits. However, the variety and dynamics in collaboration, partnerships and mergers that create multi-company enterprises need to have ready-made solutions such as integrated portals, Business Intelligence portals and B2B technology to create solutions based on specific software package-to-package paradigm. The new enterprise architecture needs to cater for virtual manufacturing that embraces a human-centric and eco-friendly approach in line with the emerging trend in globally integrated but geographically dispersed manufacturing systems.

The three models People-Centric (PCM), Molecular (MM) and Kaizen-Lean Six Sigma (KLSSM) as discussed in the preceding Chapters (3, 4 & 5) address typical but distinct features of the 21<sup>st</sup> century organisations but are still inadequate to address the complexities of modern business. The un-denying fact is that people are the heart of economy and

business; PCM precisely advocates for this notion whereas MM attempts to explain the micro-transactional feature of individual output against economic output and/or productivity. KLSSM preaches continuous improvement as a way of life, society and to run successful businesses. All these three apparently dissimilar models have one thing common - driven by people as prime mover but are swallowed by the insurgent tsunami of globalisation. This sea-change in thinking is compelling manufacturing businesses today to think globally and act locally. In order to study and explain this vital feature for today's businesses one also needs another new model.

## **6.2 Motivation for a new model**

In view of the current business challenges as enumerated in the *Manufuturing* document and the recommendations under the *Monodzukuri* spirits (Chapter 2), a new human-centered, eco-friendly business model for virtual manufacturing is required. This model, Multi-manufacturing company virtual enterprise (MMCVE), represents a typical geographically dispersed but globally integrated business model for virtual manufacturing. MMCVE however needs to be further improved and enhanced before one could really call it a truly generic and universal model. In the following sub-section this research now discusses various considerations for motivation to develop another new model in addition to already developed three new models PCM, MM and KLSSM (Chapter 3, 4 and 5).

### **6.2.1 Virtual Organisations**

The term virtual organisation is used to describe a network of independent firms that join together, often temporarily, to produce a service or product. The ultimate goal of the virtual organisation is to provide innovative, high-quality products or services instantaneously in response to customer demands. The term virtual in this sense has its roots in the computer industry. When a computer appears to have more storage capacity than it really possesses it is referred to as virtual memory. Likewise, when an organisation assembles resources from a variety of firms, a virtual organisation seems to have created more capabilities than it actually possesses. New demands has altered organisational forms in many organisations and have flattened their structures by shifting authority downward, giving people increased autonomy and decision-making power. Virtual organisations can be very complex and

problematic; they fail as often as they succeed since strategic planning poses new challenges as virtual firms determine effective combinations of core competencies.

### **6.2.2      *People***

In a globally dispersed organisation virtual distance occurs when individuals work together and communicate primarily through electronic media in an environment where member organisations differ in terms of history, structure and organisational culture. This makes it hard to trust or be trusted by other team members. Researchers have consistently found that the members of high-performing teams see things through the same lens. That is not always the case in the virtual workforce, where shared context is often lost amid the intensive eye contact with screens instead of with other human beings.

### **6.2.3      *Process***

The era of pervasive networking has enabled all companies to carefully synchronise the processes and information they share. And as business has expanded and evolved with the network, the need to work closely with trading partners is more critical today than it has ever been. Companies that efficiently integrate processes with other members of their supply chain beat competitors to market and are more agile in the marketplace. In the high-tech industry, business process integration has been an extremely effective methodology to promote efficiency and data integrity in the supply chain. Through collaboration, the collective efforts of companies around the world have created a broad repertoire of e-manufacturing process standards that seamlessly integrate trading partners and act as building blocks for new business models.

### **6.2.4      *Strategy***

In the new era, manufacturing strategy can be defined as a set of coordinated objectives applied to manufacturing functions and aimed at securing sustainable advantage over competitors. The strategic approach must be combined with a pragmatic approach to continuous improvement at an operational level to ensure competitiveness in global markets.

A key part of a manufacturing strategy is the definition of whether products will continue to be produced at the traditional manufacturing sites, or if the cost advantages make it beneficial to set up manufacturing in geographic areas with a lower cost base.

#### **6.2.5      *Customer***

Today's customers are able to find a huge choice of competitive products at a reasonable price. The globalisation of markets means that the expansion and access of businesses to all over the world to reach the needs of the customers internationally. Now due to the advancement of technology and IT revolution there is less problems of boundaries and not only big multinationals but also small companies, who were lack of resources, can now reach the customers internationally to sell their products and services. Many big markets have emerged into one single market due to the customer's needs and demands. As a result companies have started to move away from the traditional control paradigm of the monolithic company towards managing the emergent properties of networks.

#### **6.2.6      *Information flow***

The emerging possibilities of information technology and data-communication, the globalisation of markets, and the ongoing specialisation of firms have paved the way for dispersed manufacturing network of networks as organisations manifest greater collaboration and coordination across loosely connected array of firms of varying sizes and types. 'Dispersed Manufacturing Networks' provide new perspectives of 'Dispersed Manufacturing Systems'. Companies that use the Web as a tool to improve processes, channels and human performance, and to collaborate with customers and suppliers, tended to have the strongest financial metrics.

#### **6.2.7      *Feedback***

Feedback makes to generate enhanced output and enables users to get updated information and make better decisions based on it. For the successful implementation of such a system, the extensive feedback mechanisms are required among its various components. A feedback loop which is the input for one component as well as the output for another

continuously improves the quality of information. The aim of feedback mechanisms is to allow everybody in the firm to participate spontaneously in every phase of the system.

### 6.3 Modelling Approach

Following the trail of an old paper by this research (Chattopadhyay et al, 2010f) it was observed that the multi-manufacturing company virtual enterprise model (MMCVEM), as discussed thereof, lacked in enhanced capabilities and details that would have enabled the model to reflect the true global characteristics. In order to overcome these difficulties another new model Globally Dispersed Model (GDM) is required to be developed for which a step by step modelling approach follows in the following sub-sections as hereunder.

#### 6.3.1 *Difference between business model and business process model*

In its simplest form a business model is mainly concerned with strategy and external market relationships, rather than the internal processes whereas a business process is a structured series of work activities, IT interventions and events that generate one complete service or product for an organisation's customers (Vassilopoulou et al, 2003).

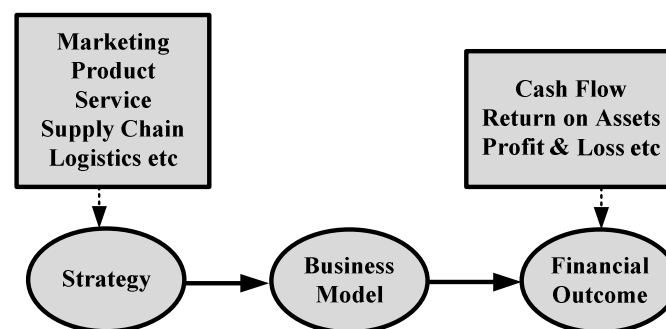


Figure 6.1 Business Model

The business model is a working description that includes the general details about the operations of a business. The components that are contained within a business model will address all functions of a business, including such factors as the expenses, revenues, operating strategies, corporate structure, and sales and marketing procedures. Generally

speaking, anything that has to do with the day to day functionality of the corporation can be said to be part of the business model. A business model outlines the essential details one needs to know to understand how a firm can successfully deliver value to its customers and driven by strategy Figure.6.1 and the term ‘business model analysis’ is widely applied in the context of strategic, financial and operational decisions by firms.

On the other hand business process models are, however, not the same as business models since business models describe what value is generated and offered whereas business process models describe how this is done. A business process is a collection of activities designed to produce a specific output for a particular customer or market (Huang, 1996). It implies a strong emphasis on how the work is done within an organisation, in contrast to a product's focus on what is done. A process is thus a specific ordering of work activities across time and place, with a beginning, an end, and clearly defined inputs and outputs: a structure for action. Thus, input-outputs are more relevant to business process model as depicted in Figure 6.2.

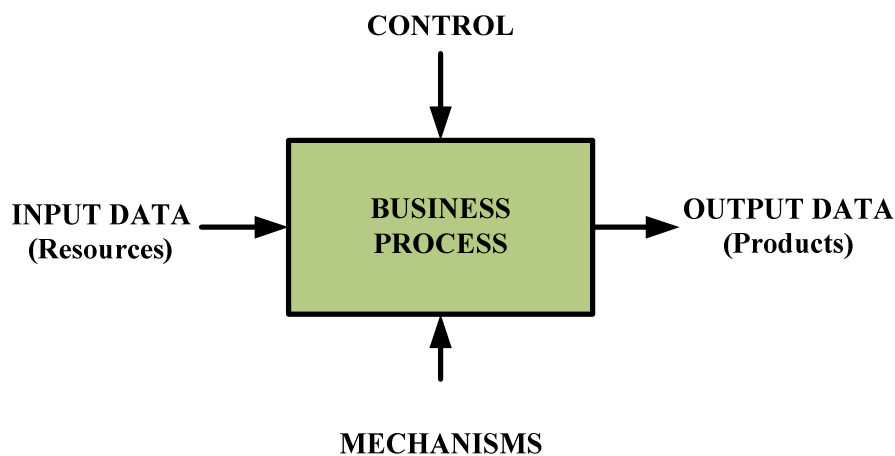


Figure 6.2 Business Process Model

A business process model, thus, justifies the need to show resources as one of the inputs and product/services as output. A business process transforms inputs (both tangible and intangible) into outputs (tangible and intangible). Business process model describes how the value is generated and offered.

### 6.3.2 *Integrated Manufacturing Information System Framework (IMISF)*

Integrated manufacturing information system framework (IMISF) is a powerful alternative that blends recent developments in manufacturing and information technology together to achieve competitive advantage. It enables manufacturing firms to respond quickly to market changes, achieve flexibility of products and processes, and manage the complexity of today's manufacturing environment (Padiyar et al, 2006).

It basically serves two primary purposes:

- Ensures organisation-wide right information flow to the right people on real-time so that manufacturers receive the necessary "on-line" information for making right decisions and are able to develop competitive strategies effectively.
- Helps to formulate competitive strategy comprising of the planning process, process capabilities and business strategies and so on.

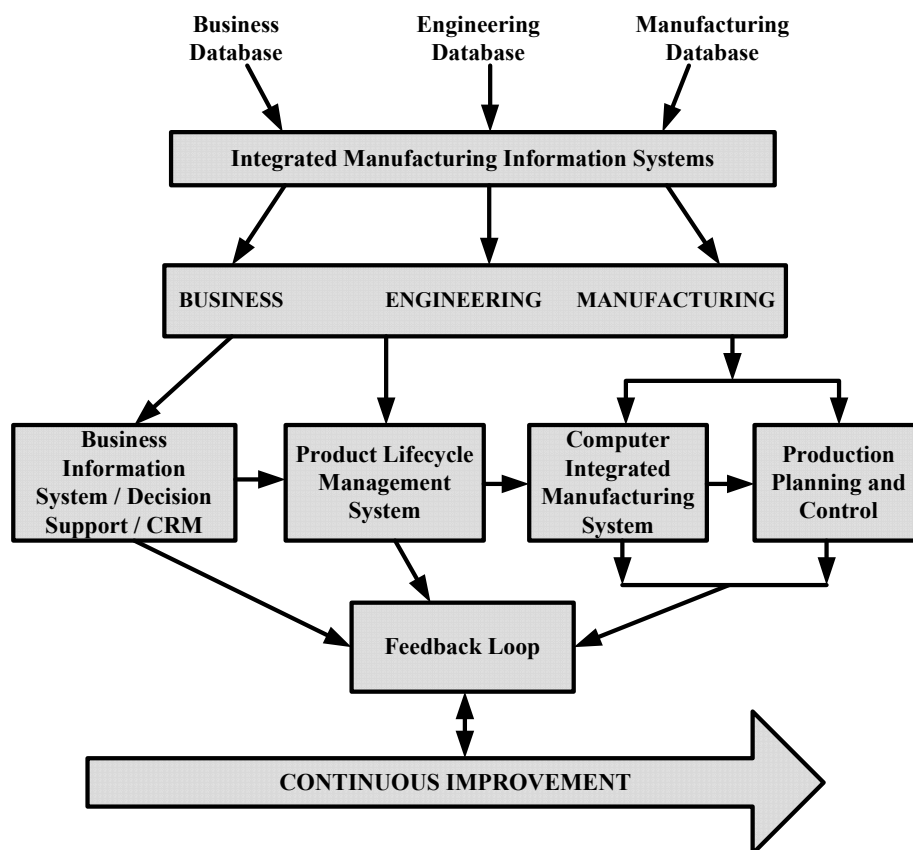


Figure 6.3 Integrated manufacturing Information System Framework (IMISF)

When properly designed it should be able to support CAD/CAM, production planning and control, product life cycle management system and business information systems. For proper coordination and performance management a closed loop feedback path ensures information access and data visibility needs to all. The overall integrated system also allows continuous improvement efforts at all levels of the enterprise. A typical framework as developed by this research (by author) is shown in Figure 6.3.

### 6.3.3 *Business Strategy Integrated to IMISF*

Implementing such a framework can often be justified by their enhanced business capabilities to integrate marketing, engineering, manufacturing and business databases into a decision support system which distinguishes it from other conventional computerised manufacturing systems, such as CIM (Computer Integrated Manufacturing) and FMS (Flexible Manufacturing System) etc.

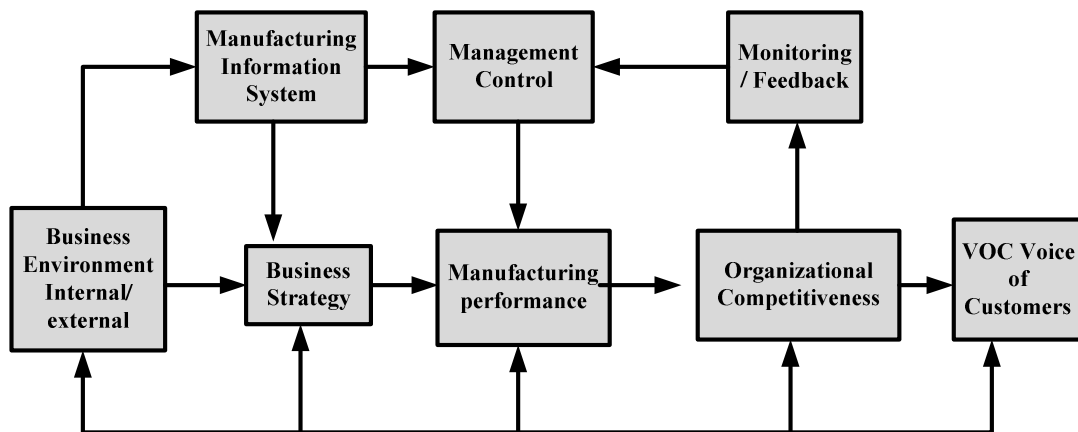


Figure 6.4 Business strategy Integrated to IMISF

Business strategy focuses on competitive advantage and emphasises creating synergies among major functional policy decisions such as manufacturing system design and product line policies. It is viewed as the way in which a firm attempts to accomplish its



organisational and manufacturing performance objectives by applying its resources to cope with the environment.

Therefore the manufacturing information system has to integrate the current and predicted business environment information (both internal and external) into the system to formulate the appropriate business strategy. Management needs to set key performance indicators (KPIs) for both manufacturing and business alike to improve overall organisational competitiveness.

The organisation has to ensure a customer-facing competitive position at all times through cross-functional consultative process and regular informal/formal feedback mechanism. Thus a framework for integrating business strategy into manufacturing information system is vital (Figure 6.4). It is evident there from that both internal and external business environment drives manufacturing information system and business strategy therefore they need to be integrated.

This research argues that manufacturing performance can be improved through appropriate management control based IMISF. A customer facing organisation needs to be tuned with the voice of the customers (VOC) to improve its own business competitiveness with the help of built-in monitoring and feedback mechanism. A careful formulation and implementation of business strategy directly drives the manufacturing performance which in turn influences the organisational competitiveness. Thus, they are all interrelated and interdependent.

#### **6.3.4      *Eco-friendly Manufacturing Modelling Framework (EMMF)***

Any manufacturing shop floor model has to have a hierarchical integration and control mechanism for optimisation that demonstrates how goals and tasks are handed down to lower levels Figure 6.5.

In order to orchestrate seamless operation regular feedback mechanism down the line needs to be ensured for monitoring and control purposes at the individual and cross-functional team level. That is why the planning horizon may range from milliseconds to months. At the enterprise level, the hierarchy is responsible for the mission of the enterprise to be followed by facility/plant, shop, cell down to equipment level having different but interrelated functions and responsibilities. The level and intensity of the control functions

increase through the levels from strategic planning to real time operational control in a typical shop floor management hierarchy model.

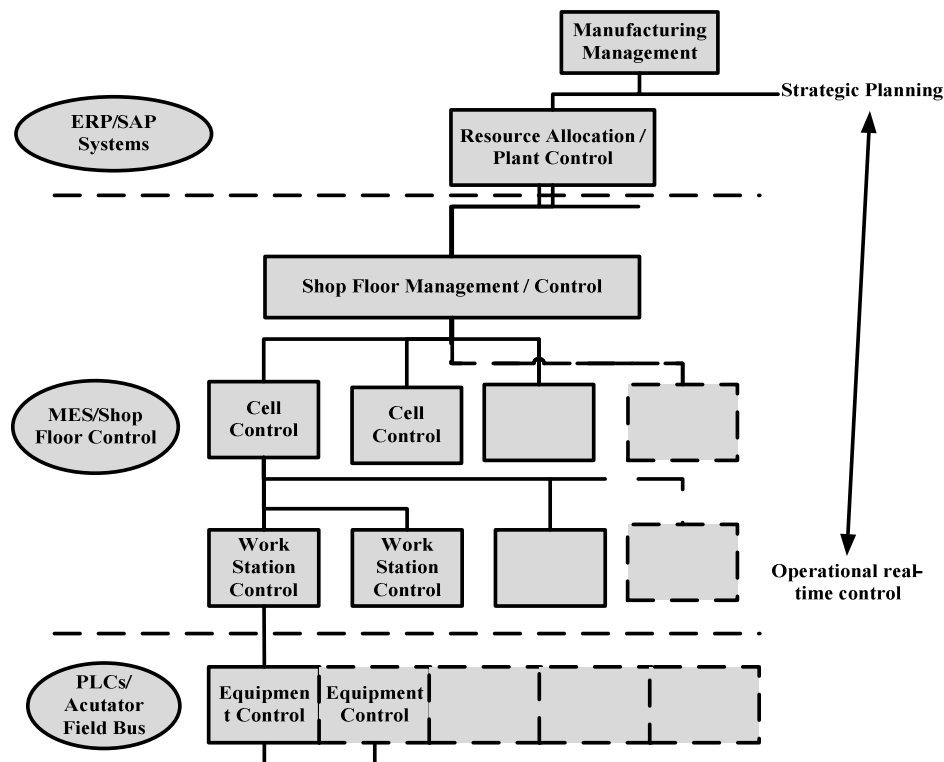


Figure 6.5 Manufacturing shop floor model

In operations management, an operational model is based on the notion that it consists of two information flows and one physical flow and these flows need to be integrated and synchronised. Two information flows are: logistical information flow that is required to ensure the product delivery, flexibility and reliability at the minimum cost etc. whereas the other information flow is the product information flow required to manage and control production resources to transform raw materials to finished products as depicted in Figure 6.6. In this diagram an integrated information flow (comprising of two information flows) has been shown vertically as opposed to horizontal material and resource flow.

Materials and products need to be routed through the machines and people with the help of appropriate material handling equipments. One of the objectives of manufacturing shop floor management is to effectively execute the optimal production (horizontal flow) using the (vertical) information flow on real time basis. Both vertical and horizontal flows also

need to be properly integrated for synchronisation and speed of production flow. The task of controlling the resources and materials (horizontal flow) on the shop floor in synchronisation is one of the key objectives of manufacturing enterprise integration and popularly known as Manufacturing Execution System (MES).

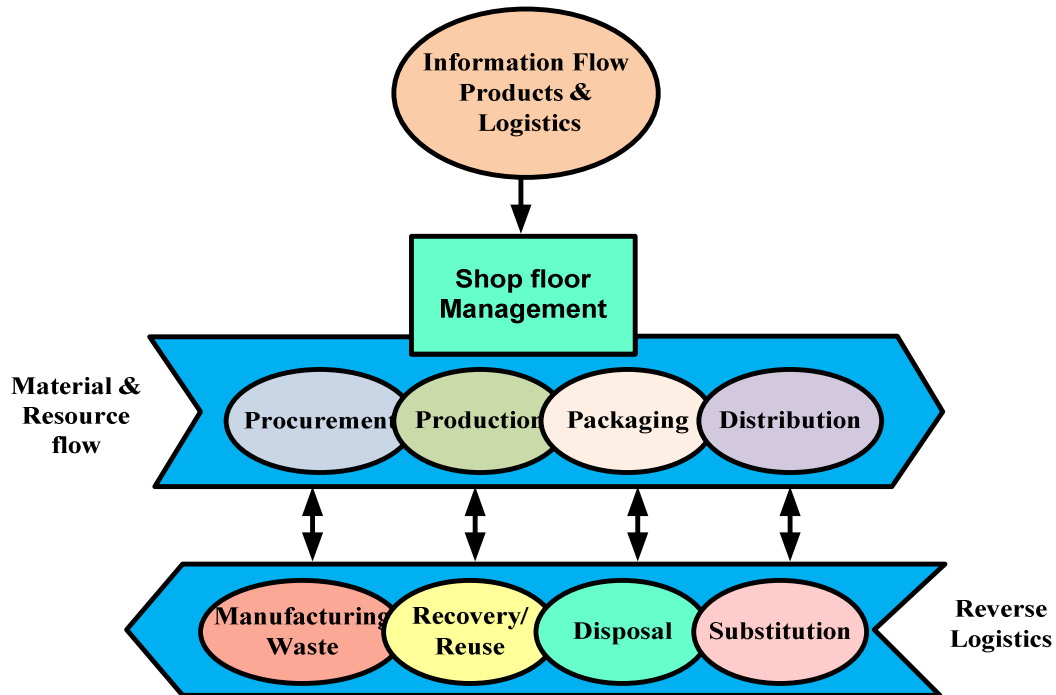


Figure 6.6 Eco-friendly Manufacturing Modelling Framework

MES is also responsible for the comprehensive scheduling of manufacturing activities in the production system. It launches work orders, track production activities and quickly respond to random events and so on.

The current global trend is pushing for sustainability in manufacturing. By making slight modifications sustainability goals such as using less material and energy, reducing waste, recycling, increasing workplace and product safety or considering alternative energy, can be reached with the existing MES systems.

This research has developed a manufacturing business integration model that would not only ensure effective shop-floor control but also be effective in reusing materials from various

sources such as disposal, manufacturing waste through appropriate recovery and substitution process adopting principles of reverse logistics (Figure 6.6). This particular feature makes the modelling framework eco-friendly integrating IMISF into it.

## **6.4 Human-Centred Globally Dispersed Framework (HCGDF)**

Following the lead from the various modelling considerations and views the Globally Dispersed Model (GDM) firstly integrates its business model into the EMMF then implants a human-centered manufacturing system in its heart shadowed under the PCM.

### **6.4.1 *Human-Centred Approach***

The core essence in the human-centered approach is the human-centered manufacturing system, for example cell production, based on environment-conscious framework. Such a system is supportive of better teamwork through knowledge sharing. In any company people are now considered as one of its most valuable assets to gain a competitive position contrary to the traditional techno-centric design view where people were merely seen as an extension of machines, a source of error and unreliability in production.

Humans with unique characteristics such as judgement, flexibility, adaptability, experience, and sentient knowledge (feel for the process) can enhance existing industrial systems and are therefore essential components in industrial systems.

Literature review reveals that manufacturers today need to construct and design inverse manufacturing systems consisting of assembly and disassembly systems for environmentally-conscious manufacturing. Such inverse manufacturing and disassembly systems have already been constructed and are being operated in Japan to produce and recover various kinds of products such as recycling of cameras, copiers, computers etc. Due to growing awareness on climate change and greater push for sustainability, manufacturing engineers in the 21<sup>st</sup> century are under constant pressure to consider additional environmental factors from product design to process selection. Material waste, tool change or disposal, raw material consumption, landfill costs, waste storage and disposal costs and

by-product material reuse etc. are of much greater concern today as the push towards sustainable manufacturing is intensified.

Although some researchers (Shiotini, 2007) did discuss about the need for human-centred approach or sustainability in manufacturing and/or reuse of materials and so on, they are mostly in different contexts and fall short of a comprehensive approach to a strategy driven business model for manufacturing.

These shortcomings are now addressed in the newly developed Globally Dispersed Model (GDM) where a strategy driven business model is integrated with a human-centred and eco-friendly approach.

Under the changing landscape in manufacturing large corporations are moving towards a globally integrated but geographically dispersed business model. The emerging trends suggest more IT spending on collaborative decision environments in multi-enterprise business networks. Multi-company enterprises now co-create value through collaboration, partnerships and mergers and so on. Various e-business platforms continue to create solutions based on specific software in the package-to-package paradigm. Under this option, protocols of knowledge consisting of interface and data definitions/standards present the core architecture enablers for the integration of enterprises.

Despite stand alone data standards that can exist outside an application, wherever possible, one needs to avoid proprietary systems and select (public) open standards from the point of view of cost. Data transport mechanisms among members can follow internet standards. Industry standards are still evolving to facilitate seamless data exchanges, regardless of the source application. In the mean time, interface layers need to be designed so that various enterprise components can be plugged in at will which typically means a hook 'on' or 'off' option. This suggests that a totally integrated operational and tactical ICT (Information and communication Technology) view need to be considered.

In a distributed manufacturing facility the need for closer cooperation, synchronisation, planning and control, data transfer and many other issues become critical and integration of those parameters are becoming increasingly difficult amongst partner companies. Sometimes it might become so complex that it might not be economically viable.

Under this backdrop this research now discusses the need for a Dispersed Production System Framework (DPSF) prior to the development of the Globally Dispersed Model (GDM).

#### 6.4.2 *Dispersed Production System Framework (DPSF)*

In a globally dispersed manufacturing enterprise, the collaborating partners need to be connected through their respective interfaces to the main data bus where the lead enterprise is also connected. According to the need and/or choice the lead enterprise is always able to hook “on” or “off” other intending partners/contractors etc. on 24/7 basis.

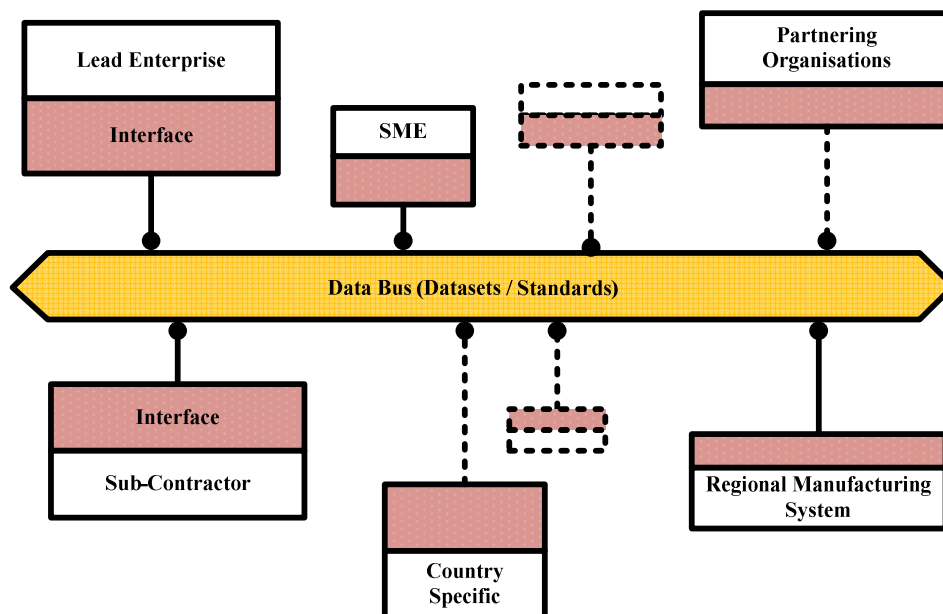


Figure 6.7 Dispersed Production System Frameworks (DPSF)

This framework thus provides a collaborative decision environment to the partner companies Figure 6.7.

Only companies in the first tier supply chain are shown here with blank white boxes representing different partner companies with different sizes and hierarchical forms/structures. It may be noted here that these partner companies may be connected to their own local, regional or country specific second and/or third tier of their own in turn thus

providing option of creating a network of networks of contractors, consultants, SME's and so on. This imparts the required flexibility in the framework.

## 6.5 Globally Dispersed Model (GDM)

GDM represents a holistic approach for virtual manufacturing that embraces a human-centred and eco-friendly approach in line with the emerging global trends in manufacturing.

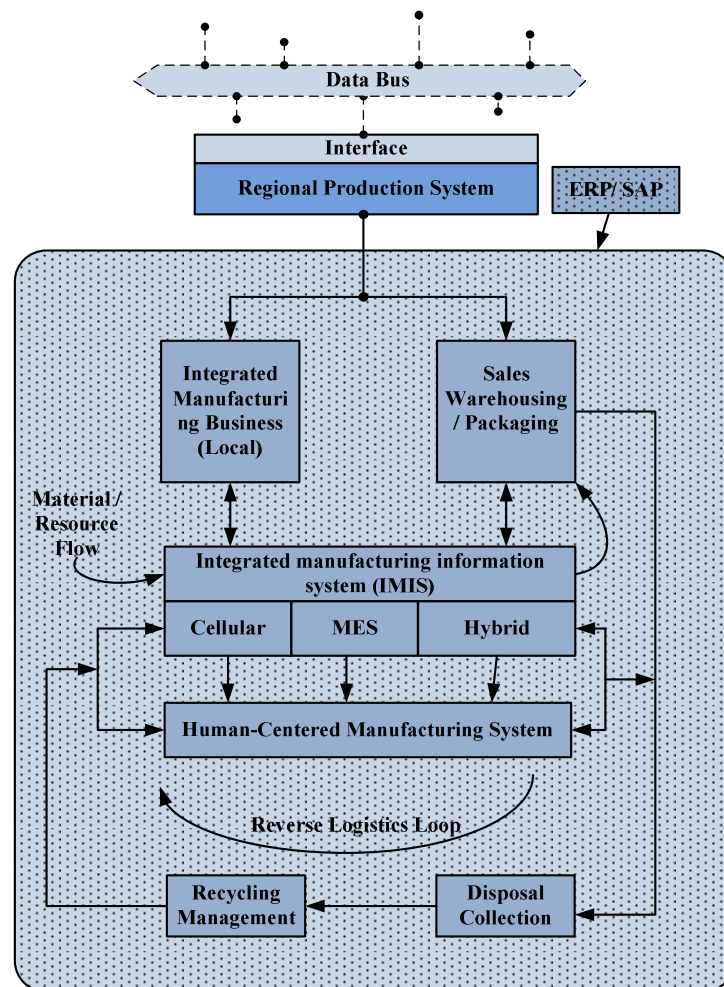


Figure 6.8 Globally Dispersed Models (GDM)

In the heart of the GDM is the human-centered manufacturing system which augments cooperation between humans and technology and thereby enhances the efficiency of the system. This thesis argues that any socio-technical system working according to the

principles of human-machine symbiosis have a serious potential for achieving not only better efficiency with lower costs and higher productivity, but also potential for overall enterprise optimisation in the sense of (business) excellence Figure 6.8.

Pragmatic use of human-centered design principles and criteria can significantly help in finding meaningful suggestions for improving synergy between humans and machines in complex socio-technical systems. The results of this synergy are visible at an increased level in other (business) excellence indicators, as measured by the human-related criteria:

- Leadership,
- People skills (S),
- Resources (R),
- Information (I),
- Partnerships and
- People/customer - societal networks.

In this model the human-Centered manufacturing system is embedded into the overall manufacturing information system framework comprising of cellular, MES and hybrid sub-systems. The manufacturing system is further integrated to the business model incorporating so far ignored other functions such as marketing and warehousing, packaging and so on.

Thus the GDM is truly a human-centered and eco-friendly outfit that embeds the integrated strategy driven business model for manufacturing information system. This model incorporates the core essence PCM and MM in term of human role and the philosophy of continuous improvement in KLSSM.

GDM model is generic in the sense that its form remaining same the constituent sub-models within (contents) will vary according to its geographic location, socio-economic, cultural and political factors. It represents the fundamental building block of the Dispersed Production System Frameworks (DPSF). Irrespective of whether the lead enterprise or any other partnering organisation will have a GDM in its core and would be connected to the regional production system through its own interfaces. Thus various local, regional and country-specific partnering organisations will be hooked on to the global data bus.



The globally dispersed model (GDM) facilitates the concept of global shop floor with “design anywhere, make anywhere, sell anywhere” strategy by providing singular, closed-loop management of demand, capacity and resources, and outbound order fulfilment across the entire network of manufacturing plants along the supply chain. It also advocates for a human-centred, eco-friendly approach and subscribes the triple bottom line (People, Planet, and Profit) goal for sustainability.

Data gathered from the global shop floor is connected to corporate-level intelligent decision support tools, creating visibility and intelligence on operational data. It enables manufacturers identify problems, isolate root causes, understand the state of execution processes, and adopt corrective actions quickly across multiple plants.

It is obvious that all plants in the globally dispersed model will not be identical. In fact the factory capabilities in different geographic locations would be different depending on the local economy, cost of labour, regulatory conditions and industrial relations. The concept of GDM allows a centralised provisioning, analytics and global process optimization, while recognising and supporting necessary localisation.

## **6.6 Application of GDM to Flowserve, Australia**

Flowserve Corporation is a manufacturer and service provider of a range of flow control equipment for the oil & gas, process, power, chemical, nuclear and water treatment industries. The company has developed precision engineered equipment to meet the unique needs of many industries and has manufacturing capabilities in the USA, Europe, Asia and Australia. The company sells its products and services to construction firms, OEM manufacturers, distributors, resellers and end users. The company employs 14,000 people in more than 56 countries. Flowserve Australia is a unit of Flowserve Corporation and supply a complete range of the world’s leading control & process valves, actuators, digital & analog positioners, controllers and switches.

Following a number of visits to the Flowserve operations in Melbourne and discussions with their Senior Executives an integrated business model framework for Flowserve was developed. During the case study it was also observed that the strategic hub in Melbourne is

responsible for its own manufacturing as well as overall coordination of logistics, import/exports, supply chain, accounting and sales/service function of its others operations in Australia and overseas. The inbound supply chain is responsible for procurement from both imported and local sources. Outbound logistics is responsible for the distribution of the finished goods (products) to customer through various channels (wholesaler/retailer/direct or any other combination including direct export.

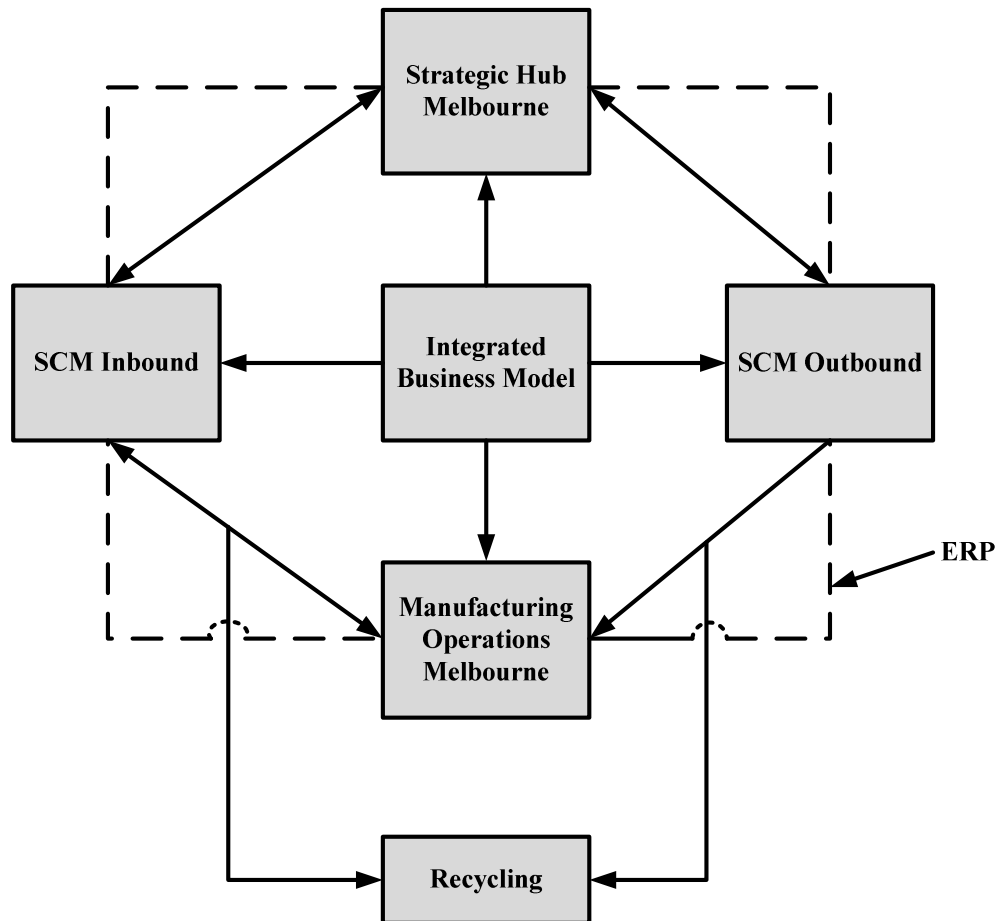


Figure 6.9 Integrated Business Model (Flowserve, Melbourne)

The integrated business model oversees and controls the entire value chain through consultative and collaborative process to deliver the best products and services to Flowserve customers locally as well as globally Figure 6.9.

All manufacturing facilities of the company are supported by a recycling facility on site to collect disposal from assembly/maintenance, process and reuse them effectively.

An ERP (Enterprise Resource Planning) extended by the parent company in US supports both inbound SCM (Supply Chain Management), manufacturing information system including inventory/shop floor management/resource allocation etc. and also extends partial support to outbound SCM (distribution) at Flowserve.

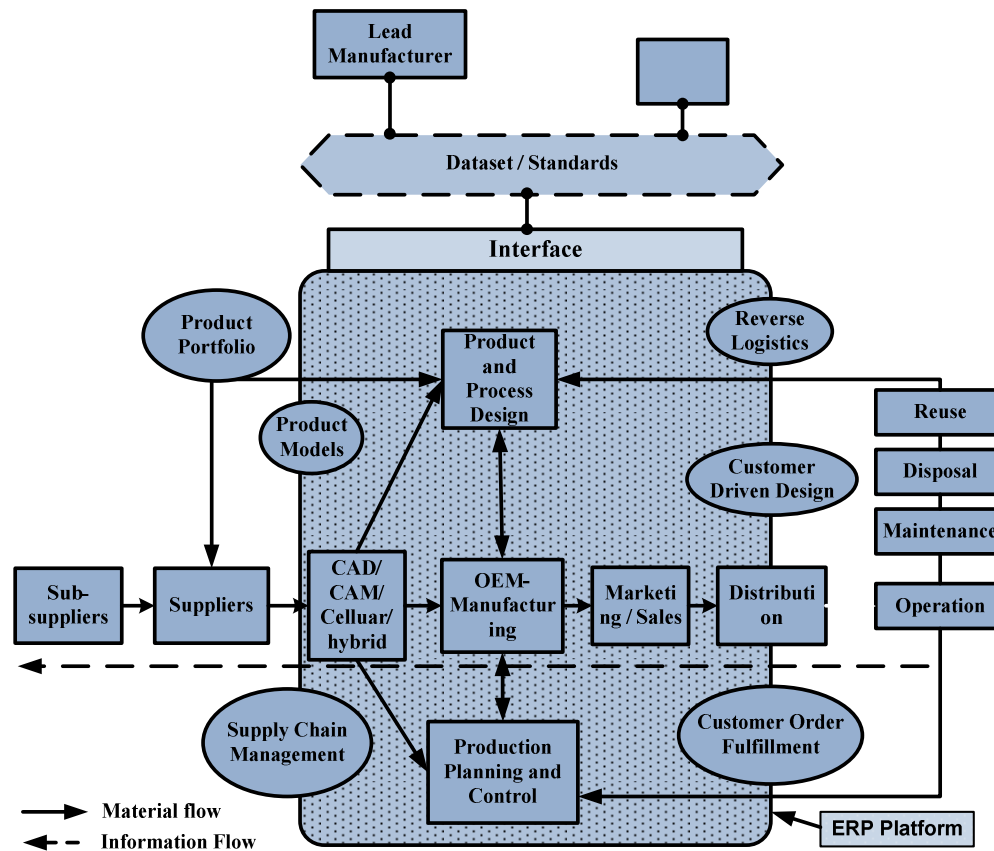


Figure 6.10 Supplier, Manufacturer & Distributor ERP-support (Flowserve)

A cellular manufacturing facility is in place to control the variable-variety and variable-volume assembly lines in tune with the customer demand. CAD/CAM is used for in-house manufacture of parts/components as appropriate.

Flowserve has a human-centered work culture. In their manufacturing facility, they have user-friendly work stations where workplace safety is a priority. They operate through various work teams. Keys to their success lie in the empowerment and trust on their employees. The company also strictly adheres to its eco-friendly culture with an onsite facility to reuse salvaged parts/components/sub-assemblies. Disposal from manufacturing operation and maintenance are scrutinised and recycled without compromising with the

quality standards. The factory in Melbourne represents the regional manufacturing system comprising of its own supply chain members and is connected through their own interface to the strategic unit also located in Melbourne. The strategic business unit is connected to the parent company through the global manufacturing data bus.

## **6.7 Chapter Summary**

Multinational Enterprises have become increasingly global, locating manufacturing plants overseas in order to capitalise on cheaper labour costs or to be closer to their markets. More recently, some multinationals like Apple have become "virtual firms" outsourcing most of their production to other companies, mainly in Asia.

Under this paradigm shift in thinking and competitive business environment, traditional manufacturing industries are slowly becoming more of a service-based industry. Even though the physical processes of manufacturing have not changed, the actual locations of where the goods are being produced have. This fact is now compelling industrialised countries to engage in more assembly driven activities – a service-based model. The manufacturing process has transformed into obtaining parts and reassembling them into the final product.

This chapter has developed a step by step modelling approach for a globally integrated but geographically dispersed manufacturing system through GDM. The GDM represents a holistic approach for a business model for virtual manufacturing that embraces a human-centric and eco-friendly approach in line with the emerging global trends in manufacturing.

## **Chapter 7            Disaggregated Value Chain Model (DVCM)**

### **7.1 Introduction**

Value chain is a high-level model of how businesses receive raw materials as input, add value to the raw materials through various processes, and sell finished products to customers. The value chain categorises the generic value-adding activities of an organisation. It describes a series of value-adding activities connecting a company's supply side (raw materials, inbound logistics, and production processes) with its demand side (outbound logistics, marketing, and sales). By analysing the stages of a value chain, managers have been able to redesign their internal and external processes to improve efficiency and effectiveness.

Disaggregation generally means breaking a firm into its strategically relevant activities for the purpose of understanding the behaviour of costs as well as the existing and potential sources of differentiation. The concept has been extended beyond individual organisations. The industry wide synchronised interactions of those local value chains create an extended value chain, sometimes global in extent.

The notion of value Chain disaggregation comes from companies that start to disaggregate the production process and focus each activity in the most advantageous location. Individual components of a single product might be manufactured in several different locations and assembled into final products elsewhere - PCs (personal computers), for instance. Another example is the recent trend by U.S. companies to offshore some of their business processes and IT services.

In a disaggregated value chain each portion of the supply chain is located in a separate area with relevant expertise within a region. Parts are then assembled in yet another location.

In an increasingly mobile and connected world, global corporations stand to simultaneously increase efficiency and lower costs by taking full advantage of the growing expertise and specialisation in emerging economies. With the lifting of restrictions and regulations, a number of nations have seen thriving sectors as a result of MNC (Multi-National

Corporation) entry, and building particular skills and expertise that continue to make them competitive in the global marketplace. Loosely defined as the relocation of business processes from one country to another, off-shoring is currently one of the most hotly debated aspects of globalisation.

As part of the global disaggregation of the value chain, it provides a critical template against which to view the intertwined issues of geography and the multinational firm. This disaggregation is the outcome of firms combining the comparative advantages of geographic locations with their own resources and competencies to maximise their competitive advantage.

This typical feature of the disaggregated value chain arising out of multiple and diverse competencies across wide cultural and geographic spread with varying technologies and disparate resource infrastructure cannot be explained and/or analysed with either one or all of the previously discussed four models. Moreover today's businesses are more of a collaborative and sharing conglomerate of skills, resources and information that individually create and co-create values for the ultimate consumer in a networked and digitised economy.

This model was conceptualised during the first visit to Development Consultants (DCL) in Kolkata, India. This company's ([www.dcpl.net.in](http://www.dcpl.net.in)) Indian operation (originally known as Kuljian Corporation) is headquartered in Kolkata and has a large base in US headquartered in Philadelphia, Pennsylvania. They are a multi-discipline engineering and architect firm specialising and providing services to energy and power plant engineering sectors around the globe. They have assembled a team of more than 400 of the finest consultants, architects, and engineers, with expertise in mechanical, civil and structural, and electrical engineering, as well as architectural, instrumentation and control engineering, and CADD design work. They also have a large pool of contractors, entrepreneurs and consultants similar to WorleyParsons (WP) in the PCM (Chapter 3) but operate under a different strategy. Unlike WP they have their own manufacturing operations as well. DCL has a work culture where grooming and supporting young technical entrepreneurs as prospective supply chain members is always emphasised and encouraged. This triggered the curiosity to study this company further since the Globally Dispersed Model (GDM) could not really explain their unique global strategy. The concept of value sphere as has been introduced in this research (under literature review) also required to be elaborated and enhanced hence the

necessity for another new model was felt leading to the Disaggregated Value Chain Model (DVCM).

This model is built upon the blended core essence of all the previously discussed four models yet embraces the value sphere concept in the current net-economy (Internet/social networking). DVCM gives a facelift to PCM, MM, KLSSM and GDM while plugging their individual weaknesses as below:

- PCM lacks the transactional characteristics of MM
- MM lacks in the indispensable continuous Improvement feature of KLSSM
- KLSSM lacks in the global features of GDM and finally
- GDM lacks in the in the key strategic concept of Value chain, value networks and value sphere

The DVCM being discussed in the following sub-section is an “All-in-All” modelling approach.

## **7.2 Motivation for this model**

The motivation for this new model came from literature review and visits to DCL, Kolkata. In order to develop the Disaggregated Value Chain Model (DVCM) a number of factors needs to be considered as being elaborated in the following sub-sections.

### **7.2.1 *People***

Talent and attention relate to the human ecology of an organisation. Focusing on the core really boils down to leveraging people in the value chain. In other words, getting the right people and getting the most from them. Successful companies (like DCL) know it's not necessarily core business processes that give them an edge anymore. Today's competitive landscape comes down to management and leadership expertise at all points along the people value chain.

### **7.2.2      *Process***

The value creating activities occur at two levels, i.e. within the industry in which an organisation operates and within the organisation itself. As such, there are two components of the value chain, namely the industry value chain and the organisation's internal value chain. The industry value chain is made up of all the value-creating activities within the industry, starting with the basic raw material and ending with the delivery of the final product into the hands of the consumer. The organisation's internal value chain consists of all the value-creating activities that reside within the processes and people of that organisation.

### **7.2.3      *Strategy***

Value chain analysis requires an organisation to determine activities that are denoted as strategic value chain activities. These are activities that give the organisation the potential to create value for the consumer in a way of creating and sustaining competitive advantage. Failure to link value chain activities to strategy results in huge wastage due to performance of activities and processes are no longer compatible with organisational strategy and emphasis being placed on non-strategic value chain activities.

### **7.2.4      *Customer***

The customer is the source of value, and value flows from the customer, in the form of demand, to the supplier. That flow of demand is manifested in the flows of orders and cash that parallel the flow of value, and flow in the opposite direction to the flow of supply. By streamlining the processes that generate the goods and services that customers value, fewer resources need to be expended, and the margin between customer value and the cost of delivery increases, improving a firm's profit margin.

### **7.2.5      *Information flow***

By exploiting the upstream and downstream information flowing along the value chain, the firms may try to bypass the intermediaries creating new business models. The value chain model treats information as a supporting element of the value-adding process, not as a



source of value itself. In other words when performed through and with information the value-adding steps are virtual. This new business practice requires that the value chain disaggregation process identify new IT based activities that add value to the firm. Thus the assessment of value chain is relevant for not only Internet companies, but for brick and mortar businesses as well. A value chain disaggregates business functions into a set of activities. A business model differs from a value chain in that it illustrates the process flows between the various value creating activities of a firm. As with value chains businesses must modify their models in response to change in the competitive environment. That justifies the need for this new DVCM.

#### **7.2.6      *Feedback***

A value chain system improves design, engineering, sales, and customer service through a closed-loop feedback mechanism. If the manufacturer decides to modify a product's attributes, for example, change management processes and documents - such as design specifications, engineering diagrams, cost allocation, or schedules - must be generated and shared between the manufacturer and supplier. It improves the efficiency of this process, reducing time-to-market, product errors, and rework. It can also provide feedback to the supplier if users report failures or marketing develops additional product requirements.

The feedback loop, which is highly dynamic, allows for a more precise understanding of the strategy's impact, while it is being refined. This dynamic process is critical since organisations can face various internal and external events that impact their decision making.

The literature review and the field studies revealed that at the micro-level, firms from both advanced and emerging economies are globally dispersing their value chains to control costs and leverage capabilities.

Acceptance of a value offering is contextual and is dependent upon the functioning of the whole network or system of value. In other words, a deliverable is considered value in one context but not in another. Value is therefore an emergent property of the network, so understanding the functioning of the network as a whole is essential to understanding exactly how and why value is created. This holistic approach emphasises the need of

feedback loop at the role level to understand one's role in the network and manage one's value inputs and outputs. Value is continually being negotiated in this context of overall purpose and values. Sustainability of the network is dependent upon there being a high level of both transactional and network perceived value. Therefore an EA should reflect both the value creation at the individual level and value co-creation at a team level of the network.

These aspects were not answered in the previously described models i.e. PCM, MM, KLSSM and GDM therefore another new model is required to fill the gap and DVCM being discussed in the following sections precisely does that.

### **7.3 Modelling Approach**

Value is a perceived view in the eyes of the beholder and is highly conditioned by the larger social and economic environment through which complex and numerous interactions affect the human perception of value based transactions. Advertising, social trends, and economic conditions all influence consumer and business valuations of products, services and resources flowing through the value systems in the global economy.

Apte and Mason (1995) argue that increased competition and volatility of margins is tearing the traditional value chain off into disaggregation. Giant corporations are disaggregating into small autonomous business units to combat fierce competition in the complex business environment today.

That is why the value chain concept has become a staple idea in the management and research literature and is the focus for evolving strategies, enterprise models and numerous efforts at improving business performance.

#### **7.3.1 *Value Chain and Supply Chain***

In common parlance, a supply chain and a value chain are complementary views of an extended enterprise with integrated business processes enabling the flows of products and services in one direction, and of value as represented by demand and cash flow in the other. Both chains overlay the same network of companies and are made up of companies that interact to provide goods and services.

Today's customers are demanding transparency in both upstream and downstream operations of the enterprise thereby blurring and diffusing the boundaries between supply chains and value chains. As a result value chains becoming value grids. They are inherently non-linear, complex and dynamic enabling nearly a limitless web of opportunities and have become an integral part of ongoing corporate decision-making process. Thus at a dynamic level, enterprises must continually explore, evaluate and map the broad competitive landscape.

A clearly-enunciated corporate strategy must be simple and tied explicitly to the critical value drivers. Therefore, the key to creating value and maximising its retention is to create a value sphere that harmoniously balances strategy, resource allocation, performance metrics, and organisation culture with customer perception.

From product development to manufacturing process, firms are now hunting for their "Task" based value chain resulting in geographically specific clusters of capabilities in the global value networks where individual tasks (components or designs) achieve value through better coherency.

Global Manufacturing is pulling new technologies into products or production processes - integrating skills, knowledge, and components from other firms.

Value Chains may be Monolithic (Integrated) or Disaggregated. In a Disaggregated Value Chain (DVC), key value generating activities take place across units or locations within and also with a number of independent organisations acting as suppliers, distributors, producers in a network structure. DVC manages the flow of goods and services along the entire value chain as Value Adding Partnership (VAP). Some of the advantages of DVC are:

- Reduced organisational complexity and bureaucracy
- Ability of individuals to concentrate and specialise only on its core competence intra or inter - units in the chain and
- Flexibility or agility to change constituent entities according to particular customer needs

### 7.3.2 Value Sphere

At an atomic level, an enterprise comprises of various value spheres created by either individual and/or cross functional teams utilising, applying and/or sharing their skills and resources over different time spans. Individual value creation or co-creation within teams ultimately reflects an enterprise's both tangible and intangible value output. A customer perceived value sphere for a product or service is, therefore, the resultant of these tangible or intangible value spheres of an enterprise. At an enterprise level the supplier/producer value output has to match, satisfy and fulfill the customer expected total value sphere (tangible and intangible).

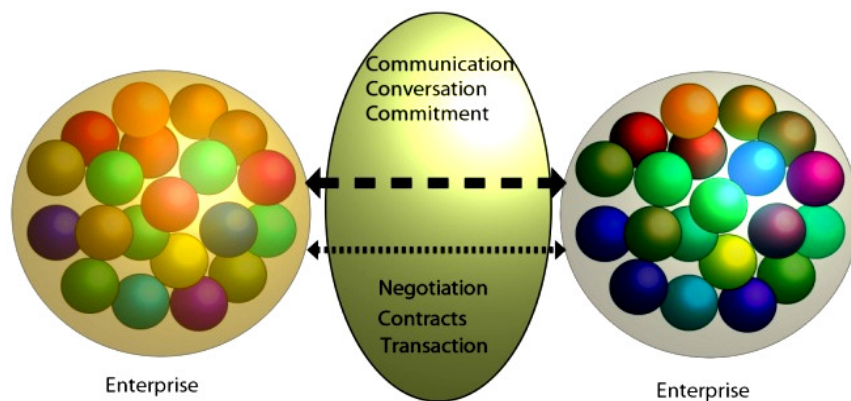


Figure 7.1 Value spheres created and co-created by People

In a dynamic business environment people continuously interact within an organisation and also with other stakeholders such as contractors, suppliers and agents and so on Figure 7.1 to individually create and collectively co-create value spheres.

‘Aggregations’ and ‘Value Chains’ concepts are more hierarchical, passing down vision and strategy and usually a top down approach. The disaggregated value sphere is fundamentally a network of people comprising of employees, management, contractors, consultants, customers, entrepreneurs and so on. In a disaggregated value sphere employees, partners and customers continuously co-create the value of a product and/or service through out its entire life cycle Figure 7.2. Therefore it may be perceived as value adding collaborative partnership (VACP). Creativity, innovation and mutual trust are the key ingredients of VACP.

As information moves in lightning speed undue secrecy between partners, win-lose negotiating, and an insistence on exclusive supplier/partner relationships are fast outmoding orthodox industrial-economy thinking.

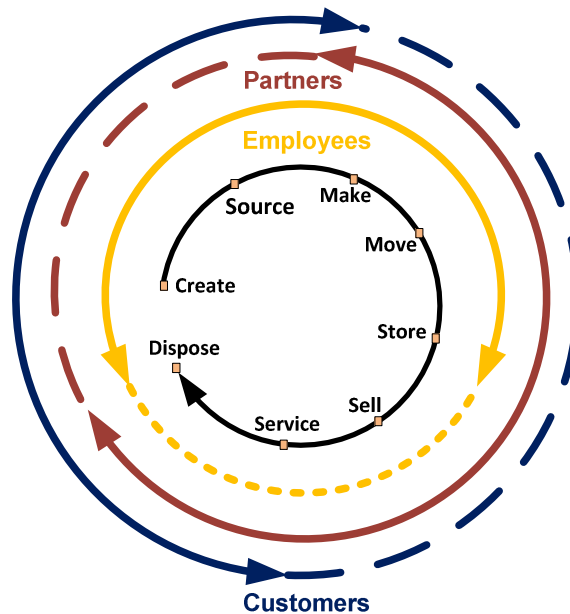


Figure 7.2 Disaggregated value Sphere

In today's competitive world everyone must be accountable for contributing to end-customer value. Business processes have to ensure customer satisfaction at each stage, from product design to post sales services and support. The customer's role is important in value creation. Customers become economic units creating and depleting value, exchanging value and setting value goals, which are met by value propositions. In disaggregated value sphere customers design and co-service the products.

### 7.3.3 *Human Network of networks (HNON)*

At the core of a disaggregated value chain is a human network of networks that orchestrates material, information, logistics & transportation, material handling, customer needs and transaction flows to ensure seamlessly integrated and synchronized operation thereby improving the effectiveness and efficiency in a disaggregated value sphere.

The policy of corporation disaggregation, spinning off parts of their business, has resulted in globally dispersing their value chains to control costs and leverage capabilities. Traditional enterprise management methodologies cannot resolve some of the problems associated with disaggregated value chains or grids.

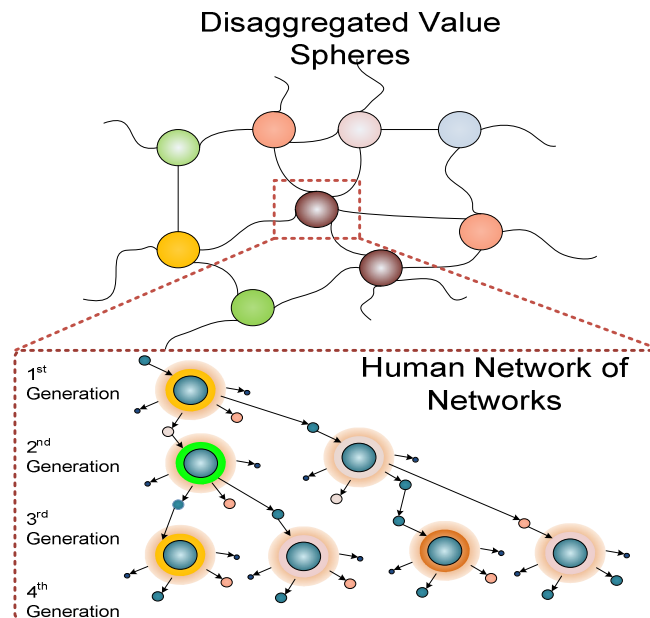


Figure 7.3 Disaggregated value spheres as HNON

In order to address this problem this research argues for the disaggregated value sphere as a human network of networks and is depicted in Figure 7.3.

Therefore from the modelling perspective a disaggregated value sphere may be seen as a network of value spheres created and / or co-created by employees, partners and customers. In a disaggregated value sphere, therefore, the cash flow originating from a project and/or business opportunity or a major transaction gets dissipated through a human network of networks and cascades down the line to the individuals or groups who happen to be the ultimate beneficiary of the transaction.

## 7.4 Disaggregated Value Chain Model (DVCM)

The Disaggregated Value Chain Model (DVCM) is developed to explain and explore the behaviour of a disaggregated value sphere in the fall out of the disaggregated corporations.

One of the important requirements of DVC is the need for high and sustained level of trust amongst individuals within a business unit and members of the VACP. Humans play a pivotal role in the disaggregated value chain. They use their knowledge, skills and resources that are available around them to produce individual outputs that have a tangible value in a realistic world. The difficulty in modelling these activities is the fact that human creativity, innovation and enormous problem solving capacity are mostly intangible and non-quantifiable. These human traits cannot be valued in terms traditional and accepted business norms or cost mechanisms.

#### 7.4.1 Description of the DVCM

In section 4.4.1 a synchronized material and material flow cycle in servicing customer needs in supply chains in a closed loop ‘demand-design-develop-deliver’ cycle (4D).

In a manufacturing environment, people can move anywhere in the organisation according to the functional needs, tasks and priorities and/or any other business requirements. These fast transitions of people add new dimension to their roles and relations within the organisation and outside.

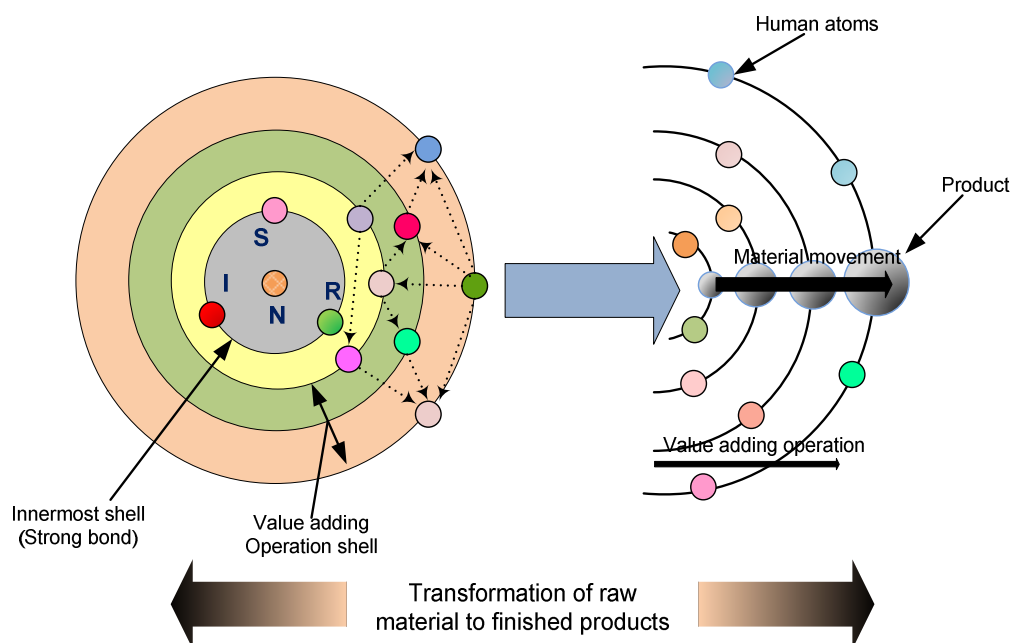


Figure 7.4 Movements of Human Atoms in Orbital Bands

The dynamics of such complex relationships between people, resources and information against time need to be modelled in the organisation. In order to model such complexities one has to focus at the micro (human) and macro (organisation) architectural level of the organisation.

The key operational functions such as planning, scheduling, shop floor management and control etc are also performed by the human atoms in these bands. As the value adding operational activities mature towards completion, incremental human energy is continuously spent by the human atoms to collectively transform raw materials to finished products Figure 7.4.

A supply chain transaction is triggered by the customer demand driven product life cycle activities. All subsequent manufacturing activities including planning, scheduling and shop floor management etc are then embedded in the “develop” and “deliver” phases of the DVCM. The supply chain feeds raw materials, parts and sub-assemblies etc to the required value adding shells/orbits in synchronization (e.g. Just-in-time etc). During the transformation processes of raw materials to finished product, human atoms as individuals or members of cross-functional teams push the product into its outermost orbits. This completes the loop of the ‘4D’ loop of the DVCM.

#### **7.4.2      *Modelling Flow in DVCM***

The dynamic behaviour in a typical manufacturing assembly sequence is visualised in Figure 7.5 and is shadowed under the MM. The lean core leadership nucleus (N) acts as ‘catalyst’ to influence the core capability process chain. It also influences the human atoms to change orbits frequently either as individuals, groups or as cross functional teams around a new project and/or prioritized job. The synergy as visualized, in the snapshot, here employs just-in-time (JIT) technique where synchronised material flow has been shown in parallel to the sinusoidal (assumed) workflow with the disaggregated value chain comprising of employees, partners and customer moves in the opposite direction to the synchronised work flow in the process chain.



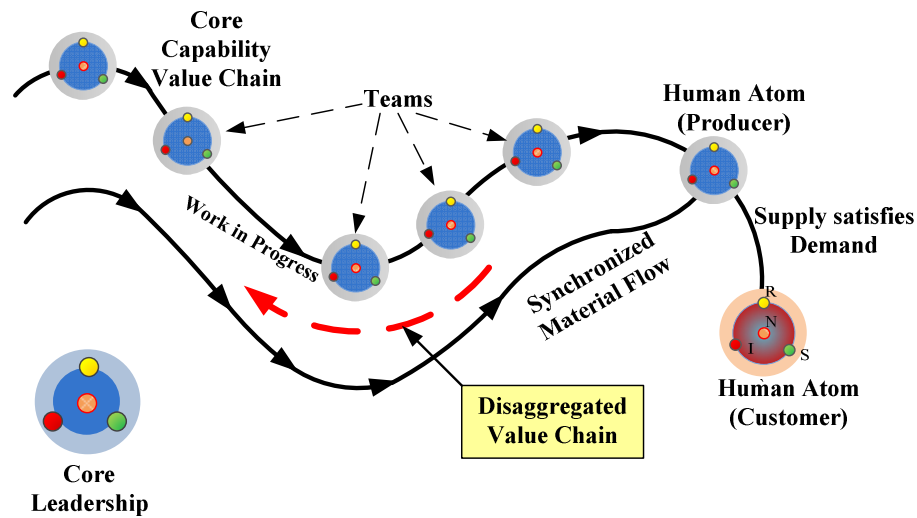


Figure 7.5 Disaggregated Value Chain opposite to the supply chain

The supply chain members (Partners) feeds the supply chain as the manufacturing process progresses from raw materials to finished products, the customer (VACP) slowly aligns itself (like docking) or vice versa, till the finished product is delivered and consumed. The disaggregated value chain (DVC) is perceived by the customer as the total value created and/or added by a product or service in terms of cost in any transaction.

This modelling flow closely resembles the core essence of the 4D model and offers a better transparency of the entire value chain to the customer.

### 7.4.3 Supply Chain 4D

The path of the disaggregated value chain sits in opposite direction to the supply chains in a closed loop ‘demand-design-develop-deliver’ cycle (4D). This is because the customer perceived value of a product traces back to the triggering stage of a job order (Demand) in the supply chain. From this stage onwards i.e. Design – Develop – Deliver gradual value addition and co-creation takes place. In other words value gets disaggregated in the opposite direction to supply chain (Figure 7.6).

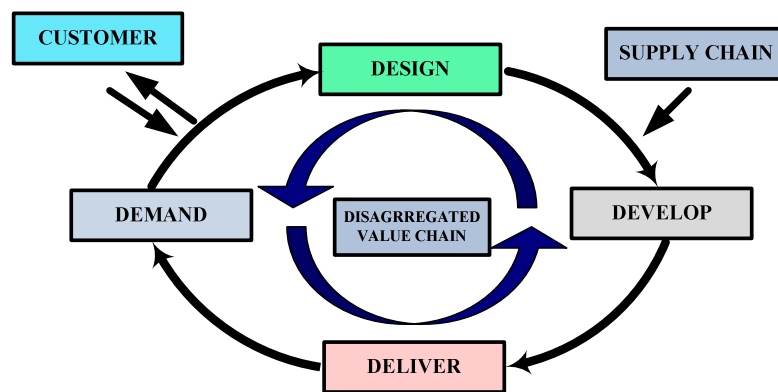


Figure 7.6 DVCM with synchronized material and information flow in a 4D closed loop

A supply chain and a value chain are complementary views of an extended enterprise with integrated business processes enabling the flows of products and services in one direction, and of value as represented by demand and cash flow in the other.

## 7.5 Application of DVCM to DCL, India

Since the inception of this company (as Kuljian Corporation) in 1941, DCL has been providing expert solutions to some of the most complex energy needs in the world

While their focus has been and continues to be on energy and power plant engineering, as a multi-discipline engineering and architect firm they have developed effective strategies for other projects as well, including desalination plants, air quality control systems (AQCS) and cement plants.

With its parent company headquartered in Philadelphia and the global hub for the Middle East and the SE Asia in Kolkata (India), DCL operates relying on a huge pool of experts, contractors, entrepreneurs and consultants from a diverse range of disciplines along with its own team comprising of more than 400 finest consultants, architects, and engineers, with expertise in mechanical, civil and structural, and electrical engineering, as well as architectural, instrumentation and control engineering as employees.

The disaggregated value chain model as applicable DCL can also explain its global operation based on mutual trust and co-creation of customer value.

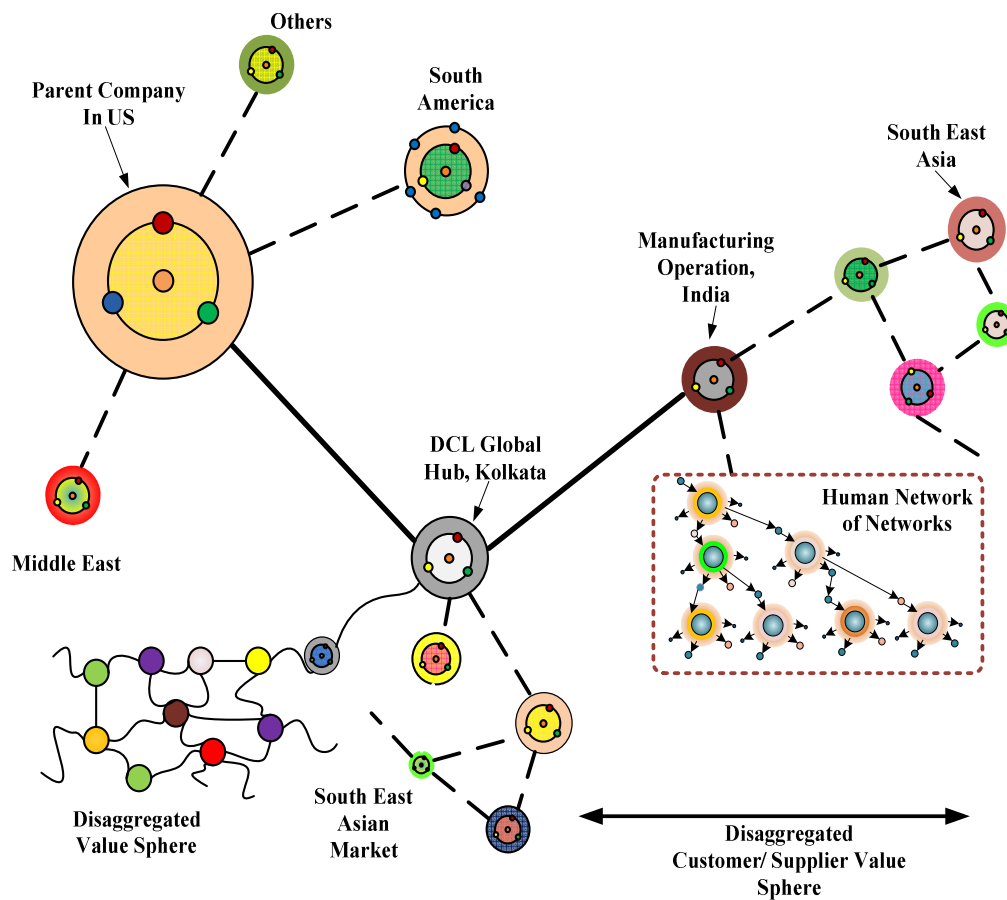


Figure 7.4 DVCM view for the case study at DCL, India

Mutual trust among employees, partners and customers of the VAP (Value added Partnership) is the key to the disaggregated value chain (DVC) success in DCL (Figure 7.7).

## 7.6 Chapter Summary

Large corporations in the 21<sup>st</sup> century that are spinning off parts of their business to the disaggregated autonomous small business units are likely to reduce or surrender their ownership interest. The policy of corporation disaggregation brings problems that cannot be resolved with traditional enterprise management methodologies. It is also generally believed that an inability to share knowledge effectively amongst disaggregated value chain members means that though one business unit is aware of an opportunity, others are not, and the moment is lost. The Disaggregated Value Chain Model (DVCM) is developed to explain

and explore the behaviour of a disaggregated value chain in the fall out of the disaggregated corporations. Based on these concepts the 4D disaggregated value chain model was developed following a step by step procedure and showing the modelling flow through visualisation of a manufacturing scenario. Lastly the newly developed DVCM was analysed through the lens of a case study.

## **Chapter 8      Pentatomic Organization Model (POM)**

### **8.1 Introduction**

All the five models PCM, MM, KLSSM, GDM and DVCM discussed in the previous chapters (3 to 7) are sub-models and lack a holistic approach since they reflect specific domain characteristics of an enterprise. Flattening of hierarchies, establishing customer oriented business segments or introducing distributed production management software, always have to consider potentials and limitations at the operational level. Therefore people, resources and information technology have to be treated equally with expertise and conceptual methodology to form a holistic system. This does imply that a technologically feasible solution is not necessarily the solution required for positive system performance.

Today's enterprises are much more extended, inter-connected, geographically dispersed and operating under constantly changing business environment in terms of strategy, customer requirements and all other operational matters while attempting to satisfy the appetite of a very diverse range of stakeholders. Despite being developed in a cascaded manner these models cannot and should not operate in isolation in order to take a holistic approach across the enterprise. Therefore all these models need to operate under a system that offers flexibility and choice to the modeller that derives maximum complimentary benefits to the whole organisation.

A federation implies a loosely coupled system distributed across the Internet or an intranet, where the participants can join in and leave the federation without breaking the federation. It also implies that participants are autonomous independent entities that can function on their own when they are not a part of a federation. An entity can participate in many federations at the same time and membership in a federation is not static. This represents the reality for independent businesses or strategic business units. Each organisation typically maintains its own software systems PLM (Product Lifecycle Management), ERP (Enterprise resource planning) and Workflow and so on that cannot be dependent on systems of other organisations

The federated approach is in line with these business trends, provides a low risk alternative to existing technology investment strategies, and enables organisations to bring new technologies in a modular fashion as opposed to implementation using a silver bullet approach. The federation approach leverages software solutions available from several vendors to support multiple, geographically distributed companies collaborating on programs. Furthermore, a federated architecture enables programs to implement a total systems view and optimise their partners, collaborators at a global level and unlock the organisation's inherent value.

Today's enterprises are not only very complex but also demands constant change in order to adapt to the dynamic, global business environment. Therefore it is desirable that an enterprise possesses a number of models in a repository or catalogue so that it can quickly adapt a 'best fit' model from it or modify the model to suit the changed circumstances instead of designing it from the scratch. In other words models should be 'reusable' in a 'plug and play' mode.

Due to the constantly changing complexity of businesses (both internal and external), it is extremely difficult to have a unified and integrated model that would be capable of addressing all "what if" scenarios. Therefore this dissertation argues for a "sub-model bank" with a number of recommended options ready to be deployed and/or deployable with minor modifications quickly, easily and at minimum cost. This paves the way for a federated model with switching options so that an enterprise may "hook on" or "hook off" any sub-model(s) or a combination thereof at will or by choice. One needs to remember that modelling is a continuous effort and not a one off exercise. Success is governed largely by the accurate assessment of the external business environment, business needs and customer requirements, strategy and cost and so on. So what is therefore required is a backbone model with switching options such that any number or combination of sub-models from the sub-model bank could be included depending on circumstances and/or need. The Pentatomic Organisation Model (POM) as discussed hereunder takes a system approach designed to extract and maximise the core benefits of five different models while plugging their shortcomings under a federated structure.

## 8.2 Federated model

Some of the major considerations in developing a federated model lie in understanding and identifying the critical characteristics of a federated enterprise. In a federated enterprise the contexts may range from a military coalition to post-merger corporate integration. A federated model therefore needs to consider some of the critical characteristics of the participating organisations in terms of its culture, leadership styles and so on (Klein and Gagliardi, 2010).

### 8.2.1 *Characteristics of Federated Model*

Characteristics	Descriptions
Culture	An organisation's culture is similar to its overall "personality." For example, some organisations operate in a highly "business-like" fashion with extensive formality of rules. Other organisations pride themselves on operating in a highly informal, relaxed fashion.
Life Cycle	The particular life cycle of an organisation can make a big difference since they often operate differently during different life cycle stages. For example, the nature of their planning, policies and procedures can change substantially between stages.
Size	The larger the organisation, sometimes more complex is the nature of its issues and even more complex the actions needed to address those issues. Usually the size in terms of the number of divisions, products and services, and the people are very critical since these features are most often associated with specific organisational issues.
Strategies and structure	Strategies refer to the overall approaches used by the organisation to effectively meet the needs of its external environment, especially the needs of its customers and stakeholders. Those approaches include how the organisation identifies the environment's needs and then uses its resources (for example, products, services, people and facilities) to meet those needs. The structures are the result of the organisation's overall strategies (the principle that "form follows function"). Structures include enterprise mission, vision, policies, plans, procedures, roles and functions.
Rate of change in external environment	Certain types of organizations are in the midst of tremendous change, for example, technologies, health care and transportation. Often, the faster the rate of change in the external environment, the more agility and flexibility an organisation ought to have in its architecture so that that it can focus on the changing needs of its customers and guide change within the organisations accordingly.

Table 8.1 Characteristics of Federated Model

### 8.2.2 *The Backbone Model*

When everything is changing around an enterprise in a non-linear, unpredictable manner it is unwise and also impractical to address all changes at the same time especially when any enterprise has a limitation on its deployable resources.

The backbone model is a particular approach to the evolutionary life-cycle model with overlapping builds which specifies that the first build of a very large system be a complete end-to-end system or backbone (Miller, 2000), which can serve as a skeleton on which the rest of the system is built. By the restriction of being an end-to-end first build, the backbone allows for early demonstration of capability since it accepts some limited set of “real” input and processes that input to produce some limited set of “real” output.

A backbone-based evolutionary system provides some advantages:

- Maximises the benefit of cycles of learning
- Starting with a simple system it helps adding functionality
- Demonstrates early capability
- Builds on potential effects of revenue.
- Provides an architecture that supports evolution of design and options to choose from
- Helps in configuration management since concurrent builds from multiple development teams is a non-trivial task,
- Multiple possibilities exist for the content of each of the builds

So a federated model has to have a backbone model around which other sub-models are built and should provide clearly established pathways for possible integration or unification as and when needed. Under such conditions a low cost switching mechanism to “hook on” or “hook off” sub-models is a pragmatic way to reduce cost of modelling.



### 8.2.3 *Differentiation and Integration*

A basic consideration for designing the operational model of an organisation is dividing work into reasonable tasks (differentiation) while giving simultaneous attention to coordinating these activities and unifying their results into a meaningful whole (integration). Generally in grouping activities the following two guidelines are followed:

- Units that have similar orientations and tasks should be grouped together. (They can reinforce each other's common concern and the arrangement will simplify the coordinating task of a common manager).
- Units required to integrate their activities closely should be grouped together. (The common manager can coordinate them through the formal hierarchy).

When units neither have similar orientations nor share their activities, the task of grouping becomes more difficult. For example, when units are similar in nature and function but are also relatively independent, the manager must base his or her decision on the most appropriate way to group activities according to his/her past experience. Experience is a learning process whose outcome is knowledge and skills over the years and being highly individualistic and therefore difficult to model (Lawrence and Lorsch, 1967).

A difficult task associated with system-subsystem determination is to establish proper boundaries of operations. The more specific and distinct the goals of the operation, the easier it is to set boundaries. Other factors such as the influence of the environment, the availability of people skills and resources such as machines, the time schedule for design and operation, the cost of alternative designs, and the particular biases of the designers must be considered when establishing boundaries.

This is a difficult choice for the modeller to set boundaries when individual sphere of influence is constantly interacting with others under the sphere of influence of the environment both internal and external to the enterprise.

#### **8.2.4      *Unification of Models under the federated approach***

Unification means gluing or stitching things together. For example the parts of the unified product keep their previous identities but they are now joined together in some manner. Integration builds on unification but it is something more. An analogy resides in the difference between a mosaic and a tapestry. A mosaic unifies pieces; a tapestry interweaves threads. Mosaic is to unification as tapestry is to integration.

Therefore when the five different models (PCM, MM, KLSSM, GDM and DVCM) in the Pentatomic Organisation Model (POM) are unified their identities should not be lost but are now joined together in a manner such that their previous identities are kept. This fundamental requirement of unification necessitates clearly defined pathways to switch from one model to the other smoothly and seamlessly as and when required. One such commonly used method is to identify and establish pathways by “Mapping” (Noran, 2003a) against the backbone model.

This research argues that PCM being the backbone-model should be used as a reference model in the federated POM with MM, KLSSM, GDM and DVCM as partial models. The combination of the partial models with the back-bone model can then become the particular model for a country-specific universal model for manufacturing system analysis.

### **8.3 Elements of Pentatomic Organisations (PO)**

Modern world lives in an era in which everything is constantly changing and the only thing that does not change is the change itself. In today's Internet-centered world and ever-changing knowledge environment, all organisations must be able to simultaneously present new and diverse faces of them in order to survive and be successful. Those organisations that fail in their ability to adapt and change according to the new emerging challenges, both locally and globally, and continue to present one static face simply cannot survive in today's competitive climate. Using enterprise modelling concepts, this research provides a standard and universal process that recognises these faces as different views and operational needs of the same organisations having similar vibrant architecture and system behaviours. They are necessary ingredients of organisations and should be embraced as a unified concept, the

Pentatomic Organization (PO). The term “Pentatomic” is derived from ‘penta’ (means five) and atomic (means indivisible composition), for modelling the complete organisation of the 21<sup>st</sup> century. PO’s appear as diverse, non-traditional and unique but they are all fundamentally identical, unified and integrated at the very core when viewed into their architectures through the anatomical lens. These findings were based on a series of studies in Australia, UK, Germany, China and India involving academics, peers and industry representatives.

The importance of developing this organisation deals with some of the fundamental issues in the organisations today. Pentatomic organisation principles will be clarified from the concept development process firstly by explaining the principles and structure of the five models that will then be unified to Pentatomic Organization Model.

Not surprisingly, many business and manufacturing managers have never even heard of enterprise architectures (EA) because most literatures in the field focus on IT (Information Technology) only. Real EA is not about IT at all, although IT is significant, it is only one small part. EA is about the structure of the whole of enterprise. It is the integration of everything the enterprise is and it does.

Organisations today may be perceived as a collaborative effort of many individuals that are in a constant flux of change and in turn influences others through their respective sphere of influence. This emphasises the need for communication between people from multi-disciplinary (cross-functional teams) and diverse cultural backgrounds (multi-cultural workforce). Chattopadhyay and Mo (2010c) have discussed the structure of POM using the five enterprise models (PCM, MM, KLSSM, GDM and DVCM). Integration of these models creates a cohesive architecture that is able to support modelling of enterprise changes in the Pentatomic Organisations (PO’s).

### **8.3.1      *People-Centric Model (PCM) in POM***

This enterprise model (Chapter 3) has been developed from a comprehensive study of a global Engineering, Procurement and Construction Management (EPCM) company. People play the pivotal role in any organisation and their presence pervades through all layers of the organisation from shop floor to the board room.

In PCM an enterprise is perceived as living because of its people. People use their skills, knowledge (tacit and explicit) and resources as available to them (tangible and intangible) to produce individual outputs. These outputs are products and/or services or parts thereof, in units of time. This is true for all people in the enterprise irrespective of their position in the hierarchy. At the micro-level, the units of outputs are therefore the product of skills, resources and time.

The organisational structure in PCM is driven by the strategy of the organisation. A strategy driven, customer facing organisation involves customer 'end to end' during the entire project life cycle. This justifies the need to include all functions, disciplines, resources and above all its people and their skills in the model. Information flow is vital to hold various elements in cohesion and acts as the glue to the structure of the organization. The PCM is therefore pivoted on people skills (S) flanked by resource (R) and information (I) and is supported by two pillars - strategy and customer.

In essence this modelling methodology can be applied to Small and Medium Enterprises (SMEs) and large corporations alike. Therefore it is generalised in that sense. That is why this model has been chosen as the backbone model in the federated approach.

### **8.3.2      *Molecular Model (MM) in POM***

The physical assets of an enterprise (say a building or machines) devoid of people will not function as an enterprise. All inanimate attributes of an enterprise from mission to structure are irrelevant without people. This model characterizes people as unique, living, animate, and yet the ultimate building block of an enterprise like the way atoms are for matter.

In the work environment people use both tangible and intangible resources (R) and information (I) to produce tangible/intangible 'output' utilising their skills (S). A supplier or producer's total output is the aggregated individual output of its people as achieved through coordinated and synchronised utilisation of various resources, business information and their respective skills. People (say employees) transform raw material into finished products with the help of plant and machinery (R), their skills (S) and Information (I) as available to them on real-time basis.

When visualised with the concept of atomic structure, at individual level, people with their brain are like atoms that use the resource and information available around them (in various orbits) to transform the raw materials to finished goods by their skills. The finished goods (output) are then supplied to a customer to fulfill their needs.

In this model (Chapter 4) any human interaction is perceived as interaction between two or many individuals and their respective 'sphere of influence'. Under this context revenue can therefore be interpreted as the earnings or cash flow arising out of the transference of either product and/or service to the customer. Basically a customer pays the provider in exchange of goods and/or services it receives. Thus the customer perceives the value as the multiplied output of people skills, resources, energy and time and so on spent to produce and deliver the output.

Under this backdrop it appears as if human atoms are moving in the factory or shop floor space retrieving required resources and applying their skills to enhance the value either individually or co-creating value in a team. Thus human atoms moving freely in the space are interacting with others. In this process of co-creation the sphere of influence no longer remains spherical but takes a variable form with an ever changing contour. In order to model such complexities one has to therefore focus on the transformation process at the micro (human) level that gradually escalates to the macro (enterprise) level, through physical movement of materials from raw material stage to finished product.

The core essence of the MM is perceiving humans as an independent, standalone, intelligent entities with key operational functions such as planning, scheduling, shop floor management and control etc. that are performed by the human atoms who are freely moving in different orbital bands in the factory space. As the value adding operational activities mature towards completion, incremental human energy is continuously spent by the human atoms to collectively transform raw materials to finished products.

### **8.3.3      *Kaizen – Lean Six Sigma Model (KLSSM) in POM***

Ideally, continuous improvement is part of a culture in which individuals and departments are aligned toward common goals - first and foremost being customer satisfaction. When

effectively managed, and with the right people engaged in meaningful ways, continuous improvement can stimulate reconciliation among organisational silos, leading to holistic change. It encourages analysis of a problem using all relevant facts and experience. Clearly this process begins with analysis, which requires good information, and thus an effective information system. When an information system provides multiple perspectives on the same situation based on a single source of fact-data, the problem-solving team begins to feel solid ground beneath their feet. Whether that information system is simple and visual, or complex and electronic, is another matter. It also encourages placing relevant information and decision-making authority into the hands of the people doing the work.

The raw data stored in a database adds value for decision-making, only if, the right information is presented in the right format, to the right people, at the right time. Raw data must be summarised, structured, and presented as digestible information. An information system (comprised of the appropriate balance of visual, manual, and electronic data capture and presentation tools) is an essential enabler of this process. When the information system is fragmented, unreliable, overly complex, and burdensome to operate, then it is counterproductive and wasteful. When properly designed, on the other hand, an enterprise performance management system supports the free flow of knowledge and continuous improvement, orchestrating the efforts of teams and individuals toward a shared purpose.

Enterprise modelling alone has not been successful in inflicting such required improvements on a continuous basis. In the past decade, the methodologies of such as kaizen, lean manufacturing and six sigma have been used to manage manufacturing organisations that need to cope with such frequent and dynamic changes.

This research has recently developed an integrated Kaizen-Lean Sigma model for Continuous Improvement (CI) that can be applied to is the latest development of this family of methodologies combining the best of both worlds. It is developed under the auspices of the Operation Phase of the Enterprise Lifecycle in Generic Enterprise Reference Architecture (GERA) as an effort towards enterprise engineering and integration. GERA also recognises that the role of humans in the enterprise remains fundamental (Chapter 5).

The core essence of KLSSM is change, innovation and transformation in the organisation. The model is pivoted on the people skills (S) flanked with resource (R) and information (I)

on either side. This model has a layered flexible EA with built-in lifecycle phases. The layered architecture embeds the unified CI tool box such as Kaizen, Lean Six Sigma and so on and can be further enriched and enhanced with other IT enabled continuous tools like SAP. To signify the flexibility for adding new tools and further enhancement, the KLSSM has incorporated a flexible extension as a pair of vertical dotted lines at the side of the central block. The long short vertical dotted lines imply that S, R and I have a pervasive role in the people-centric KLSSM and are supported by two pillars strategy and customer. The two supporting pillars along with the feedback represent the model as a simple control system. This model (sub-model) is customer facing and driven by the strategy in common with the PCM and MM in the federated PO.

#### **8.3.4      *Globally Dispersed Models (GDM) in POM***

This GDM represents a holistic and simplistic approach for a business model for virtual manufacturing that embraces a human-centric and eco-friendly approach in line with the emerging global trend in manufacturing. This model, which was previously described as multi-manufacturing company virtual enterprise, presents a theoretical view of today's complex business environment that large manufacturing firms are moving towards a globally dispersed but integrated business model. The emerging trend suggests more IT spending on collaborative decision environments and to incubate on multi-enterprise business networks delivery.

It has now become obvious that collaboration, partnerships and mergers create multi-company enterprises. Portals, Vortals, BI (Business Intelligence) portals and B2B technology continue to create solutions based on specific software package-to-package paradigm. Under this option, protocols of knowledge consisting of interface and data definitions/standards present the core architecture enablers for the integration of enterprises. In a distributed manufacturing facility the need for closer cooperation, synchronization, planning and control, data transfer and many other issues are involved and integration within these partner companies are very difficult as such when the business systems are becoming so complex that it may not be economically viable. This justifies the need for creating a framework that would define the interface specifications for partner companies to operate in a globally dispersed business environment. Therefore the developments of the

appropriate interface specifications, by which everyone will operate, are also of fundamental importance.

In this model (Chapter 6) the lead enterprise and other supply chain members/contractors are connected to the main interface bus. They can be hooked 'on' or 'off' by choice or need by the lead enterprise as shown thereof. Any number of partner companies can thus operate in a globally dispersed environment through the proposed framework on the dispersed production system.

A typical manufacturing system needs to be integrated with the business model of which sales and warehousing etc. are also typical functions. For simplicity, other typical elements of a business model such as finance, strategy, planning, business decision support systems etc. have not been shown in the model.

Material and information flow play a dominant role in the operational level of a typical manufacturing organisation. A manufacturing business needs to be also conscious and active in the reuse of disposal from manufacturing waste etc., as appropriate, through recycling and reverse logistics. This is mostly done at the shop floor level. A manufacturing business integration model ought to represent all these considerations.

In a virtual manufacturing environment, partner manufacturing facilities may be dispersed globally, regionally or locally. In order to ensure a collaborative decision environment, to incubate on multi-enterprise business networks delivery, the partners are interconnected through the GDM interface that use datasets and standards that have the key features such as interoperability, scalability etc. This model proposes a typical regional production system connected through GDM. It also enumerates a manufacturing system in the shop floor operates through an integrated and optimised combination of cellular, manufacturing execution system (MES) in order to combat the variable-variety, variable-volume and manufacture-to-order situation or a combination thereof.

### **8.3.5 *Disaggregated Value Chain Model (DVCM) in POM***

Large corporations in the 21<sup>st</sup> century that are spinning off parts of their businesses to the disaggregated autonomous small business units are likely to reduce or surrender their



ownership interest. The policy of corporation disaggregation brings problems that cannot be resolved with traditional enterprise management methodologies.

The Disaggregated Value Chain Model (DVCM) is developed to explain and explore the behaviour of a disaggregated value chain in the fall out of the disaggregated corporations (Chapter 7).

The disaggregated value chain (DVC) is perceived as a value adding collaborative partnership (VACP) amongst people who work closely together on trust to manage the flow of goods and services along the entire value adding chain.

One of the important requirements of DVC is the need for high and sustained level of trust amongst individuals within a business unit and members of the VACP. Humans play a pivotal role in the disaggregated value chain. They use their knowledge, skills and resources that are available around them to produce individual outputs that have a tangible value in a realistic dollar driven world. The difficulty in modelling these activities is the fact that human creativity, innovation and enormous problem solving capacity are mostly intangible and non-quantifiable. These human traits cannot be valued in terms traditional and accepted business norms or cost mechanisms.

In a disaggregated value chain structure, the key value generating activities take place across various units or locations within or between a number of other independent organisations acting as suppliers, distributors, producers within a network architecture or structure as the progress of value creation of the product or service moves towards its final exchange outcomes. These fast transitions of people add new dimension to their roles and relations within the organisation and outside. The dynamics of such complex relationships between people, resources and information against time are reflected in the newly developed closed loop ‘demand-design-develop-deliver’ cycle (4D) model. The 4D model is embedded in the DVCM as a centerpiece.

During the transformation processes of raw materials to finished product, human atoms as individuals or members of cross-functional teams push the product into its outermost orbits in order to complete the loop of the ‘4D’ model in DVCM.

A supply chain transaction is triggered by the customer demand driven product life cycle activities. All subsequent manufacturing activities including planning, scheduling and shop floor management etc. are then embedded in the “develop” and “deliver” phases of the DVCM. The supply chain feeds raw materials, parts and sub-assemblies to the required value adding shells/orbits in synchronization (e.g. Just-in-time). During the transformation processes of raw materials to finished product, human atoms as individuals or members of cross-functional teams push the product into its outermost orbits. This completes the loop of the ‘4D’ loop of the DVCM.

## **8.4 The Pentatomic Organisation Model**

Organisations today require a flexible architecture where need based changes can be easily embraced or adapted at an affordable cost and time frame with minimum disruption in operation.

The very vibrant nature of the Pentatomic Organisations (PO's) is due to increased significance of people and their interacting sphere of influence at its core. At the micro-level (atomic views), human atoms with their individual sphere of influence constantly interact with the business environment through the feedback channel. Human traits play a significant role in determining the shape, size and contour of the sphere of influence at the individual atomic level. Various schools of thoughts have been put forward by the academics and industry practitioners in the last century to describe humans. Economists named humans as labour; management experts call them human resource; IT Experts call them agents and the list is ever increasing from human capital to knowledge worker.

This might then lead to an inference that views on humans depend on the eyes of the beholder and are subject to individual perception and interpretation. Despite spectacular achievements in medical science the complexities of humans as a biological system of systems have not been fully discovered hence unknown. One would then imagine how complex and difficult it might be to fully understand and measure the full spectrum of human intelligence and emotion with the given knowledge and tool that one has today. On the other hand it is generally believed that each human is unique on its own. It is therefore

obvious that modelling human intelligence, emotions and/or sphere of influence is a real challenge for the researchers.

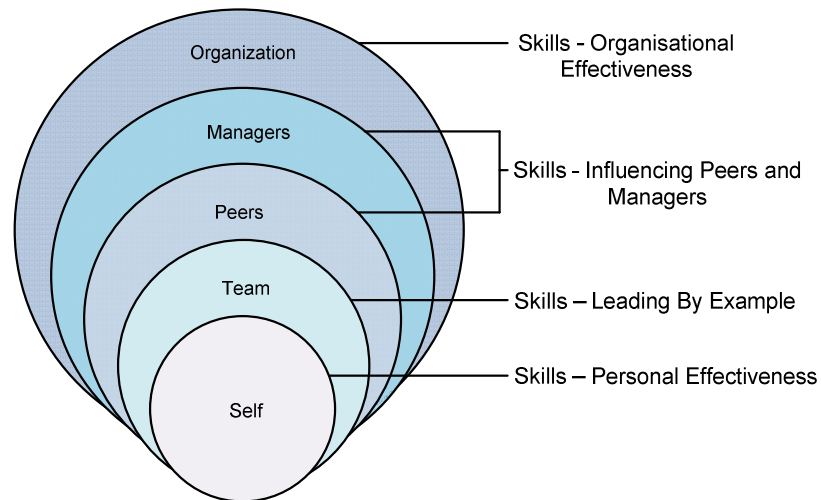


Figure 8.1 Human-Sphere of Influence

Each of the five foregoing models apparently looks different but has the same vibrant characteristics due to people in their hearts. An individual always radiates its sphere of influence onto the business environment that is extremely difficult to model.

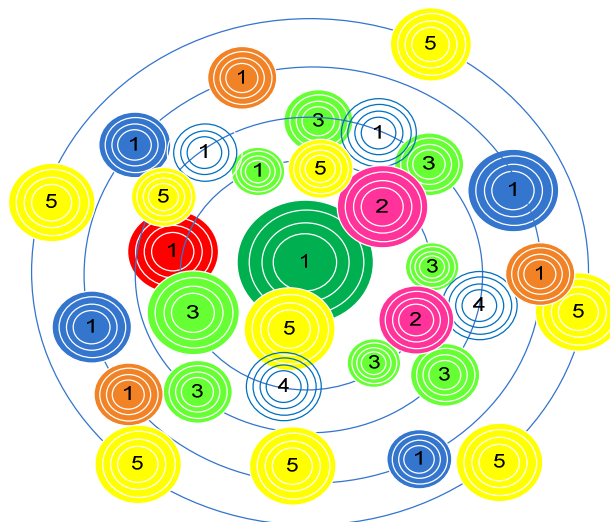


Figure 8.2 Interacting Human Spheres

Human interaction is the chemistry of actions and reactions that take place when an individual sphere of influence comes in direct contact with others in a personal, societal and professional context. Emotion plays a very significant role in any decision and is usually catalysed by personal and external stimuli. Despite uniqueness of each human sphere of influence Figure 8.1, emotion can largely influence the dynamics of an interaction and hence the outcome of a transaction Figure 8.2.

An individual may behave or react in a totally different and unexpected way at different times. This unpredictability makes it very hard to model or simulate human interactions. From an organisation point of view an individual transacts with a number of internal and external customers such as collaborators, partners, service providers and so on.

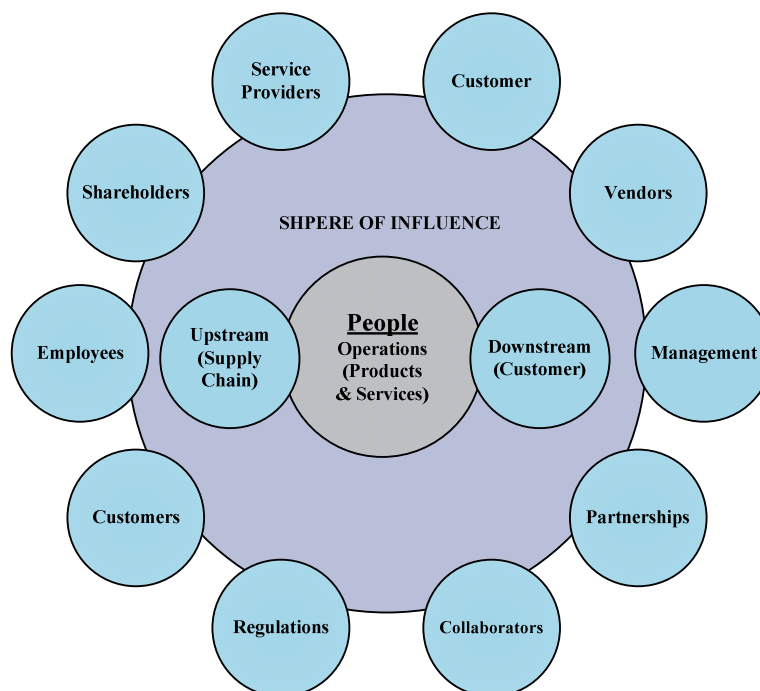


Figure 8.3 Peoples sphere of influence

The way an individual interacts in a materialistic business transaction is largely influenced by its personality, emotions, efforts, opportunities and many other human traits. These attributes are difficult to gauge and measure, being mostly intangible, and are difficult to model Figure 8.3.

Mendeleev’s periodic table is an extremely useful framework to classify, systematise, and compare different elements and their chemical behaviour. The periodic table contains only 118 elements as of today compared to 6.8 Billion world population. It is therefore impossible, if not absurd, to classify and/or group 6.8 Billion times of different human emotions (likewise atomic number in periodic table). This thesis therefore argues that each enterprise, unique on its own, comprising of individual human atoms as its fundamental building block is even much more difficult to model.

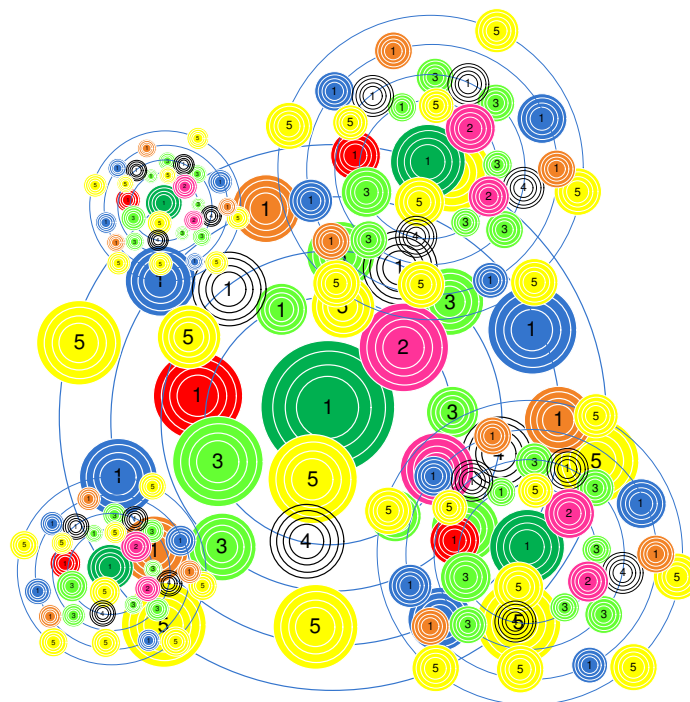


Figure 8.4 People interaction with trust and emotion

Pentatomic Organisations (PO’s) portrays only five typical enterprise operational aspects based on various case study scenarios through five different models in an endless journey on enterprise modelling where possibilities of other model remains boundless.

At the heart of the PO’s lie an interacting and dynamic human “network of networks” that orchestrate material, information, logistics & transportation, material handling, customer needs and transaction flows that ensure seamlessly integrated and synchronized operation. During a transaction an individual sphere of influence interacts with others and the dynamics becomes extremely complex and difficult to model as is evident from Figure 8.4.

In the light of the literature review and discussions on EA's in the foregoing chapters it has been observed that EA's have always been a one way process. One group designs the EA and a separate group implements it without all round consultation. A well regimented continuous feedback mechanism and governance is missing.

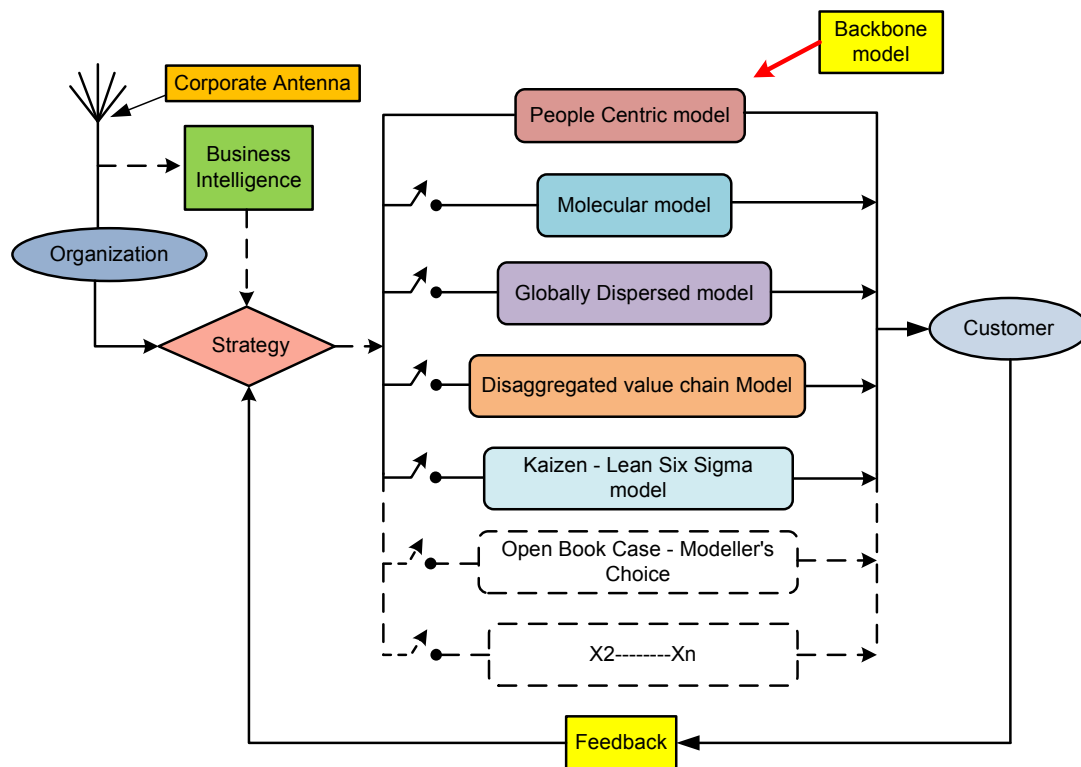


Figure 8.5 The “federated” Pentatomic Organisation Model

In the information age, organisations are moving towards more people-centric EA emphasising the need and importance of enterprise-wide communication, consultation and collaboration. In other words, a lot more consultative processes are required that seek innovative ideas of people in the enterprise and provide the opportunity to adjust the direction of the enterprise for improvement. Feedback plays a crucial role in such consultative processes.

While the five portraits of an organization, as enumerated by the five models, focus on people's roles, responsibilities and reactions, the link to vital consultative processes is missing in modern organisations. From EA's point of view, the five portraits are different

views of the same enterprise. The Pentatomic Organisation Model (POM) can therefore be developed as a federation model that adapts to different enterprise modelling requirements by enabling or disabling its constituent sub-models Figure 8.5.

The dotted layers represent options or choices to the modeller. Since all portraits are people-centric, it is logical that the PCM forms the backbone model (as shown with solid arrow) and the other sub-models are optional, that is, circumstantially required (linked with switches). The optional models can be stored in a catalogue, corporate memory or model repository and can be retrieved as required. The POM allows future expansion or adaptation of additional new models such as  $X_1 \dots X_n$  where  $n$  could be any real number of sub-models and is always  $n \geq 1$  depending on the need and strategy. This typifies POM's with choice, flexibility, adaptability and expandability and are therefore truly generalised.

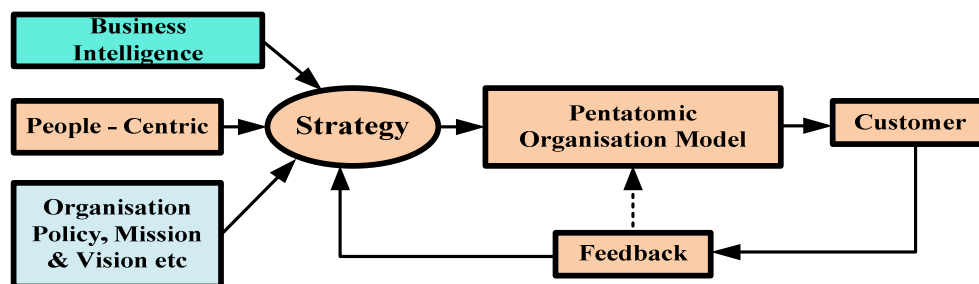


Figure 8.6 POM as a closed loop control process

The POM is driven by the expectation of customers through a feedback channel that ultimately determines the strategy that the enterprise needs to formulate. Being a closed loop control system, the POM creation process compares the customer requirements (output) with some 'desired' reference value (goals and mission) in order to formulate the strategy that drives the expandable people-centric architecture Figure 8.6. Accordingly the optional sub-models may be connected with the People-Centric model as backbone.

The iteration loops indicate the consultative nature of work relationships in modern enterprises. Consultation is a process by which people in the organisation finds a solution jointly.

## **8.5 Step by Step Modelling Approach for POM**

POM is a federated modelling framework for describing five typical models of the 21<sup>st</sup> century organizations.

### **8.5.1      *Strategy***

In POM the strategy is formulated and actioned by people comparing the business intelligence as information (I), in line with the company policy, mission and vision etc. with the customer feedback as the desired reference value. The error signal in this case determines the required combination of the rest four models MM, KLSSM, GDM and DVCM with the PCM as backbone.

### **8.5.2      *Designing the Enterprise Architecture (EA)***

Adopt an enterprise wide consultative process during designing, building and implementing the EA processes under the governance of a feedback mechanism.

- Identify the current state (AS-IS) by describing the enterprise structures and activities as an EA. Information including how IT is being used in the organisation, what manufacturing or business technologies is being used and how they are deployed to add value to the organisation.
- Document the desired future state (TO-BE), where the business would like to be from an EA perspective, taking into consideration the current initiatives involving use of enterprise resources.
- Document the "gap" between the AS-IS and TO-BE states and construct a list of projects and initiatives to close the gap, in other words, develop a "transition plan".

### **8.5.3      *People***

People with their skills (S) in respective roles and function utilise resources (R) on real time information (I) to produce variable micro-outputs individually or collectively in a value creating endeavour that sets the tone of today's upcoming people-centric business culture.



#### **8.5.4      *Backbone Model***

PCM as backbone of POM actually helps to allocate resource (R) (both tangible and intangible) to people having appropriate skills (S) for a given task prompted by the error signal. POM is strategy driven which in turn is formulated by real time business intelligence. The Role and Function layer of PCM guides the workflow in POM. In fact Strategy, R, S and I (in conjunction with the role and function layer) and the Customer of the PCM framework drives the modelling activity for POM. Layers other than Role & Function are like an open book case where the modeller may choose to put any description according to need. The need is dictated by a range of other factors such as customer deliverables, external and internal business environment, organisation capacity, time available for execution of a task/project and so on.

#### **8.5.6      *As-Is and To-be States***

Document and/or record existing company infrastructure and operational model to draw the “As-IS” state then design and draw the “TO-BE” state using the chosen optional sub-models and detailing new IT and physical asset requirements for future and the cost associated with it. Care needs to be taken here to ensure that the proposed upgrades or new system still remains interoperable under the existing system operational platform wherever possible. The difference between “TO-BE” and “AS-IS” when mapped would indicate the gap, tasks ahead and cost.

#### **8.5.7      *Cohesiveness***

Cohesion is a measure of the functional relatedness of sub-models (instructions, data definitions, etc.) within a single model. In a good design, the cohesion in a model should be high. Together with coupling, cohesion is one of the best measures of the quality of a design. A model may exhibit any of seven levels of cohesion depending on how the activities within the model are related as below:

- In sequence from best to worst, these seven levels are:
- Functional (sub-models contribute to a single, problem related activity)

- Sequential (activities within the model are connected in that the output from one serves as the input to another)
- Communicational (activities share the same input or output)
- Procedural (activities share the same procedural implementation)
- Temporal (activities can be carried out at the same time)
- Logical (activities appear to belong to the same general category)
- Coincidental (activities have no relationship to one another)

Depending on how the activities within POM are related, a comparison of the qualitative characteristics for cohesion is tabulated below (Table 8.2):

Cohesion level	Coupling	Cleanliness of Implementation	Modifiability	Understandability	Effect on overall system maintainability
Functional	Good	Good	Good	Good	Good
Sequential	Variable	Good	Good	Good	Fairly Good
Communicational	Good	Medium	Good	Good	Fairly Good
Procedural	Variable	Poor	Variable	Medium	Bad
Temporal	Bad	Medium	Good	Medium	Medium
Logical	Medium	Bad	Good	Poor	Variable
Coincidental	Bad	Medium	Variable	Medium	Bad

Table 8.2 Comparison of cohesion characteristics in POM

The maintainability of models with functional, sequential, and communicational cohesion tends to be significantly higher than that of models of the four lowest levels of cohesion. As it is seen in table, not all cohesion levels are well managed. These cohesion levels therefore present challenges for further research in POM as the next generation Enterprise Reference Architectures (ERA).

## 8.6 Application of POM to Signotron, India

Signotron, India ([www.signotron.com](http://www.signotron.com)) manufactures electronic dedicated control system for OEMs, Banking and Railways. In the railway sector the company made steady progress and

reached higher volume. The railway business also put a demand on the company to graduate to higher level of technology, power handling and sophistication.

Presently the company has a turnover about \$7 Million. Based upon the strength of the expertise of power electronics, the company expects to operate in two new verticals. One is the solar-power inverter with controllers and the other is industrial UPS (Uninterruptible Power Supply).

According to its CEO, the outstanding technical and commercial achievements of Signoton, as an SME (Small and Medium Enterprise), is due to the high morale and motivation of the people who have a strong sense of purpose. The management philosophy has always been to encourage everyone in the company to become innovative and responsible in their respective roles and functions so that each and every employee is able to effectively manage their own tasks and responsibilities rather than being managed from the top which reflects a typical self-managed hyperarchical organisation structure. The management also actively believes and inculcates a gain sharing culture across the enterprise that boosts morale of people and build trusts among themselves.

The success factors for Signotron are:

- A strong cohesive team
- Goodwill and cordial relation with customers, suppliers and collaborators
- Dedication and commitment by all enterprise-wide
- Deep-rooted trust amongst employees and other associates
- Smart utilisation of limited resources and data driven actions

#### **8.6.1      *Entrepreneurship/Innovation***

- Innovation is fundamental to Signotron's business model and culture where entrepreneurship at all levels is the key strategic competitive advantage.
- Alertness and prompt action driven by business intelligence and technological changes is another success factor

- Focus on short and medium term planning since long term planning was found unrealistic under the present business climate

### 8.6.2 *Strategy*

- Use of advanced technology in UPS to keep the competition low
- Sustain high level of motivation amongst all at both good and bad times.
- Accept technical challenge and put the best efforts
- Value trust and goodwill with all employees
- Plan according to market realities
- No micro-management putting the onus and responsibility back on the people to achieve the desired goal.
- Sustain technological lead in the niche market it operates under
- Avoid and/or eliminate excesses and wastages

The above organisational characteristics attracted this research to undertake a detailed case study at Signotron for validating the POM.

Signotron like all other enterprises has its problems. The main problem at Signotron is quick product obsolescence and limited product life. They guard against this with superior flexibility and agility in operations.

The case study revealed that the application of PCM as the backbone model fits well into the federated concept of POM at Signotron. The micro-architectural view of MM also can be successfully dovetailed with the PCM.

Signotron has a small office in London and Frankfurt to look after the sales and services of their products in UK and Germany. Due to limited export market, the global operation being low key affair at Signotron and the application of GDM is practically non-existent as shown in Figure 8.7. DVCM is very much operational in the domestic market and is distributed across length and breadth in India. They have a dealer network supported by a network of 'contracted' service centres at major capital cities in India.

The sub-models that are not applicable to Signotron are marked with crosses and the switches are open as against the sub-models MM and DVCM where switches are closed as shown in solid red lines signifying that both these sub-models are connected in parallel to backbone PCM. The vertical dotted red line in KLSSM signifies that Signotron practises only Kaizen and lean and not Six Sigma for the time being.

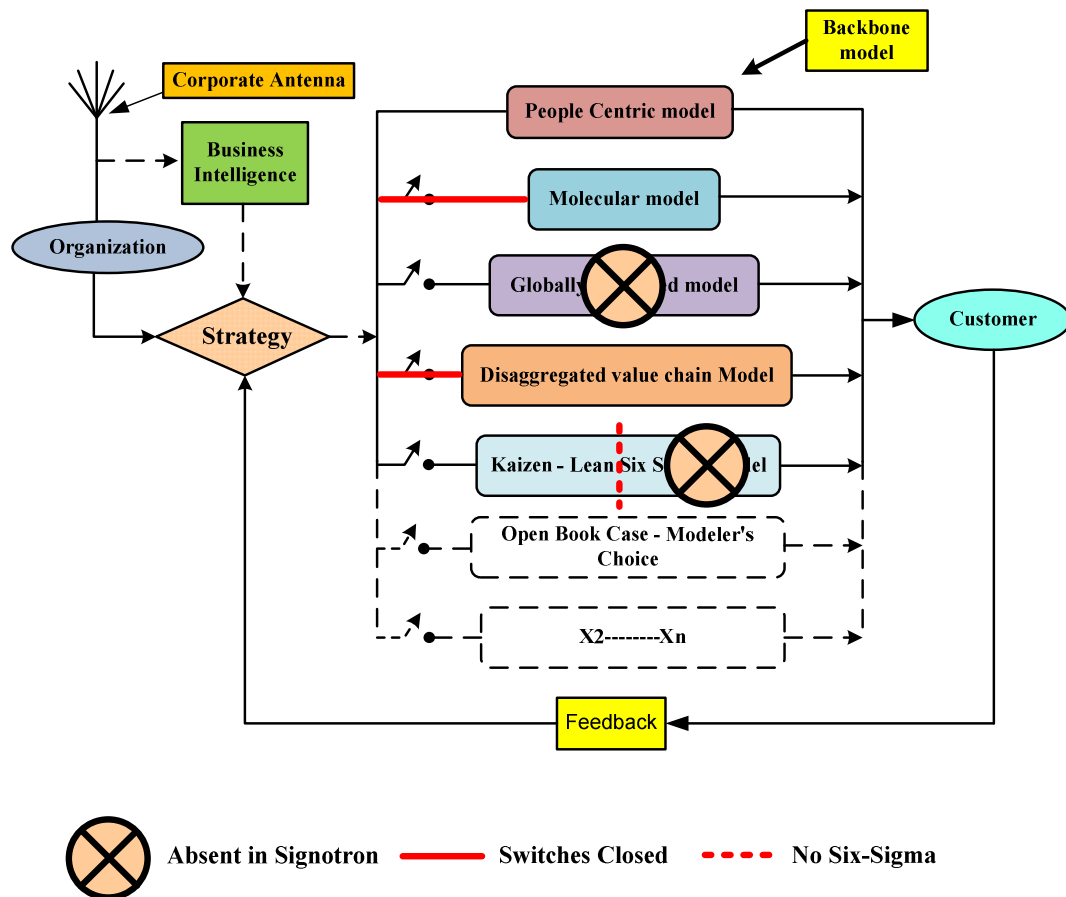


Figure 8.7 POM as per case study at Signotron, India.

The case study also revealed that application of the Pentatomic Organisation Model (POM) did increase Signotron's market (niche) share by 11.5% and cash savings by 9.5% through productivity gains. It also helped them to formulate, implement and monitor business strategy in line with the voice of the customers (VOC).

Signotron found that the five new models in the federated POM are:

- Unified, universal and applicable to both manufacturing and service industries with

people in their core

- Simple, flexible and dynamic in nature
- Understood by and can be communicated to all in the organisation using common language.
- Strategy driven, customer facing lifecycle approach for governance

## **8.7 Chapter Summary**

This chapter underpins that modern enterprises are driven by people and their sphere of influence. POM unifies apparently five different portraits of the same organisation and unifies them under a federated structure. These five portraits represent different views of the same enterprise facing different challenges in the global business environment. The unification of these portraits provides a common modelling language. This in turn helps the to manifest different attributes and characteristics for the most appropriate organisation structure to be designed and implemented. POM has a simple, flexible and dynamic structure characterised by a feedback channel that represents the consultative process of the 21<sup>st</sup> century organisations. Hence, POM could help industries to “sense and respond” to complex external business environment. The new EA can be used as a vehicle to change roles and functions of the people and allocate timely resources to them utilising information/data driven decision making process according to customer needs and is developed under the auspices of Generic Enterprise Reference Architecture (GERA).

## **Chapter 9      Discussion**

### **9.1 General Observation**

Enterprise modelling is driven by many factors such as:

- Modeller's choice, need and particular domain of interest
- Purpose and objective
- Viewpoint
- Expected outcome
- Technology available
- Timeframe
- Cost
- Communicating medium
- Complexity
- Abstraction level
- End user, Audience and so on

Designing and developing a universal model for analysing manufacturing systems is an uphill task and is unlikely to meet the varied needs and expectations of all the stakeholders in an enterprise. Situation becomes even more complicated when they are globally dispersed since the number of stakeholders, having different and sometimes conflicting interests, becomes enormously large. Therefore the only choice a modeller is left with is perhaps to focus on the specific domain of interest and develop partial or sub-models. It is obvious that sub-models on the other hand cannot represent the holistic view of the enterprise. Therefore it is essential that the modelling approach is based on commonalities of views rather than differences so that unification becomes easier at a later stage. During the process of unification, flexible options to add “on” or “off” a sub-model needs to be incorporated to suit individual needs or choices. This calls for a federated approach for modelling. Eventually all these sub-models can be stored in a repository or company catalogue to be retrieved and/or modified depending on the circumstances and priorities. In a fast changing business environment “one model that fits all” point is mute, if not redundant and is not

pragmatic either. Modelling is a continuous process and needs to be updated or refined as and when needed.

Every organisation (except to be designed or created), irrespective of its location/type and/or size, already has its own existing model and an enterprise architecture of some sort but may not be explicit or well documented. If the existing model and architecture is able to cope with the fast changing business environment satisfactorily then probably there is no need for a new model or architecture but that is rarely the case. That is why continuous modelling and EA building effort is so important for any enterprise today.

The research methodology as adopted in this research is to develop a combination of theoretical modelling methods with the enterprise case studies conducted in Australia and overseas. Lessons learnt from the field study reveals that most industry practitioners, line managers and even IT departments are not fully aware of the enterprise modelling techniques as a tool for enterprise performance improvement as compared to quality, business process re-engineering and other management tools. Even large corporations with multinational operations are unfamiliar and unaware, if not indifferent, to enterprise modelling as against some of the most popular and commercially available software such as SAP, MRP or MES. Findings of this research also corroborates with the global survey report on enterprise architecture usage amongst the top twenty countries in the world including Australia, China and India as mentioned in the literature review Figure 9.1.

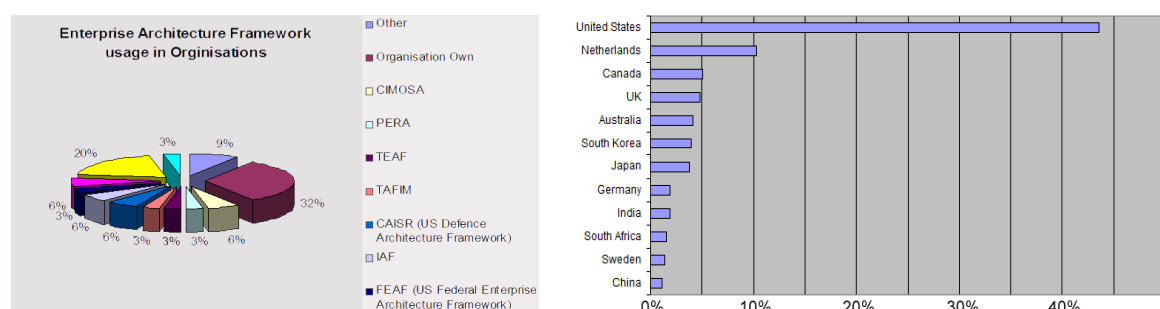


Figure 9.1 Recent declining trend in Global Enterprise Architecture Usage (IFEAD, 2005)



As has been discussed in the previous chapters, the following considerations are important before one could attempt to develop a combination of the theoretical modelling methods for a universal manufacturing system.

### **9.1.1 21st Century Organisations**

21st century organisations have the following characteristics as is evident from the literature review:

- *Drivers*: People, Profit, Customer, Quality, Stakeholders, knowledge and Innovation
- *Sustainable*: Energy Efficient (Green), lean, Agile, Adaptive and profitable (triple bottom line approach)
- *System of systems*: Complex system behaviour, flexible and e-driven
- *Collaborative network of networks*: Shared knowledge, resources and assets
- *Security and risk*: Risk management and internet security
- *Customer*: Mass customisation of products and services
- *Socially responsible*: More regulated and responsible to community
- *Globally dispersed*: Fluidic organisation structure
- *Cross cultural* : speaks many languages and so on

### **9.1.2 Modelling Views**

In general, enterprise modelling concerns the representation of what (operations and objects being processed), how much (quantity being processed), who (agents or resources that execute the operations), how (behaviour or manner through which things are done), where (logistics), and when (time) aspects. From the rich and informal natural human language to formal and precise mathematics, an array of modelling options exists, including symbolic, graphical, and semi-formal languages. For instance, an example of a graphical model is a process flow chart while an example of a semi-formal language is the Integrated Computer Aided Manufacturing Definition Method (IDEF) notations.

No all-inclusive model of an enterprise has been developed to date. That is, there is no current modelling method that is exhaustive - no matter how sophisticated, an enterprise model usually needs to be complemented by other models. Comprehensive enterprise models, therefore, are based on multidimensional descriptions and may require

computational support. Common modelling dimensions are functions, data/information, resources, organisation, and control (Sousa et al, 2001).

That is why an enterprise modeller's view is perceptual and is driven by factors such as:

- Relative perception and knowledge of the context and enterprise contents
- Domain of interest and need
- Purpose and functionality
- Audience
- Communication medium
- Modelling knowledge and so on

### ***9.1.3 EA Driven Tasks***

Anatomy of tasks can be precluded in EA as people's initiatives and hence using POM they can be managed more efficiently. The term task has many different definitions under different contexts. In the context of this thesis the task is defined as a piece of work assigned to or demanded of a person (human atom). The term "task" is often used interchangeably with activity or process. Task analysis often results in a hierarchical representation of what steps it takes to perform a task for which there is a goal and for which there is some lowest-level "action" that is performed. Irrespective of the nature of the task whether manual or cognitive, people use their skills (S), required resources (R) and real time information (I) to accomplish them. Conventionally any job or project can be decomposed into a set of tasks at the micro-level. Even at the micro-level, tasks are completed by people with the help of the three key parameters S, R and I resulting in individual micro-outputs in units of time.

It is generally believed that when a task can be accurately defined, repetitive in nature, standardised, high in number, needs no human touch and benefits outweigh investment cost - automation is recommended. But the problem is when a process or a part thereof is partially automated there is a mismatch in capacity against those performed manually. In other words partial automation leads to capacity imbalance in a manufacturing process since the efficiency and cost gained in automation is ultimately lost due lower speed of the manually performed tasks. This hybrid manufacturing environment re-emphasises the need

for a holistic approach to modelling. The other problem is with the interfaces between human and machine along with the disparities between different IT platforms. Appropriate choice of transducers, instrumentation and accuracy in measurements also pose problems for the design and operation of the interfaces. Lastly seamless integration of the system is essential. High degree of integration brings more rigidity to the system thereby impairing the flexibility. Rigid systems impart more lag and instability into the control system increasing the system inertia or latency and the system response becomes sluggish. Today's organisations need to have "sense and respond" features that can face up to the challenges of reduced time to market i.e. "zero latency" and variable variety customer requirements therefore the degree of integration needs to be carefully determined.

## **9.2 Manufacturing Model in Australia (M1)**

Import competition from low cost economies such as China and India has largely replaced Australia's labour intensive and low skilled industries as sources of consumer goods. A number of case studies involving Enterprise Architecture Mapping (EAM) with the Australian manufacturers and service providers reveal that traditional modelling methodologies are practically non-existent amongst Australian manufacturers (including SME's) except in very few large corporations and multinational organisations. Automation is used where practical and cost effective. Automotive, mining, oil & gas, banking sectors have considerable emphasis on automation and system integration. However most of these industries use commercially available software and some of them use their own customised business systems.

### **9.2.1 *Characteristics of M1***

The study of several Australian enterprises in this research (denoted as M1 in Chapter 1) has revealed a number of potential sources for the relative decline of manufacturing in Australia including the following:

- Growth in disposable income can lead to higher consumption of services, such as health and financial advice, relative to manufactured goods. This decline in share of

consumer spending directed towards manufactured goods has occurred in much of the industrialised world today.

- Domestic manufacturers in Australia are facing pressure from both a declining share of consumer expenditure and a substitution into goods that are generally produced internationally. The manufacturing sector is also facing changes in preference where consumers are more likely to purchase imported goods.
- The decline of manufacturing as a proportion of GDP (Gross Domestic Product) can also be explained by greater international competition by low wage cost countries. Declines in labour intensive industry within the manufacturing sector, such as textile, clothing and footwear are primarily victims of developing countries' cost advantage. Australian manufacturers have seen prices of imported goods relative to the price of domestic goods declining sharply in recent years. The lesson from this is that Australia's manufacturing must move up the value added chain and produce niche products. Therefore Australian manufacturers are moving away, increasingly, from the goods in which China and India are competitive.
- Increasing international trade has seen Australian businesses moving offshore in order to remain internationally competitive - a drive to sustain and improve competitiveness and shareholder value through better management of costs and of quality. Companies engaged in off-shoring are able to achieve better management of costs by seeking out lower cost locations, consolidating operations and lowering the costs of infrastructure, training and management and so on.
- Recent trend in global outsourcing of components has reduced the cost of information technology hardware by almost 30 per cent over the last decade – cost savings which have been passed on to consumers. It needs to be noted that Australian manufacturing is not just taking place in Australia but is taking place internationally.

### **9.2.2      *Application of POM to M1***

In terms of modelling approach, Australian manufacturers and service sectors (Appendix-I) shows mixed results as revealed by the recently conducted case studies. PCM (Chapter 3), MM (Chapter 4) and KLSSM (Chapter 5) in POM are common whereas GDM is used in most export oriented enterprises. DVCM is sparingly used since industries are vertically integrated and the number of supply chain members is limited. By referring to Figure 8.5, Australian enterprises can be modelled by switching on PCM, MM and KLSSM while leaving GDM and DVCM as reserved for special cases. The POM can therefore be successfully applied to Australian manufacturing model (M1) by selecting appropriate sub-models under its federated structure.

## **9.3   Manufacturing Model in China (M2)**

Investing in China provides multinational corporations access to a large and growing consumer market. Companies located in China may sell a large proportion of their goods to the Chinese domestic market (which is huge as compared to Australia) rather than exporting.

### **9.3.1   *Characteristics of M2***

The study of Chinese enterprises in this research (as denoted by M2) shows that Chinese manufacturers follow different models for their domestic and export markets. Quality and statutory compliance requirement being less stringent for the domestic market and the models vary widely in structure, form, ownership and leadership styles. However in the organised sectors and joint venture companies the scenario is different. For many ODM and OEM companies they are obliged to embrace the model, quality and business systems of the parent company. In general the business models in China are more complex and multi-dimensional. On the other hand the domestic service sectors operate in an entrepreneurial model and are not organised in that sense. Due to cultural and language barriers, entry to global service sectors are less developed in China as compared to India.

In some areas of China, particularly Shenzhen, factories are experiencing a shortage of skilled workers and are forced to pay high wages. This is a problem very familiar to

Australian employers. It is difficult to know the extent or severity of any labour shortage but it reflects the fact that countries experience many of the same problems faced by domestic companies (Global Competitiveness Report 2006-07). India is competing against Australia mainly in services rather than in manufacturing.

The comparison of the key features of trade integration processes and the economic outcomes of China and India reveals that while much has already been achieved in both these economies in terms of opening up, the Chinese reforms, especially with respect to manufacturing trade, have gone further and that this is likely one of the key determinants of better economic performance of China. China is probably the example to be followed as far as trade policy is concerned but China's integration process so far remains characterised by a certain duality. On one hand the opening up of trade and FDI in manufactured goods has spurred the emergence of a largely private and dynamically growing sector. On the other hand the high level of public ownership and important regulatory barriers continue to dominate the services sectors.

### ***9.3.2 Application of POM to M2***

The case studies with the Chinese companies (Appendix-I) reveal that the enterprise models vary widely. Traditionally Hong Kong has always been a strategic business hub (for China) and dominates in service industries. Most of the manufacturing takes place in Mainland China, Taiwan, Indonesia, Singapore and other South East Asian countries. The typical business models in Hong Kong can be well represented by POM. The particular case studies at GEW and Haier reveal that PCM, MM, GDM and DVCM are mostly used as compared to KLSSM. It is noted that quality systems and built in CI philosophy are sparingly used, although consideration for these systems is gradually in the rise especially for the export oriented joint sector companies due to pressure from foreign markets.

## **9.4 Manufacturing Model in India (M3)**

India has gone a long way in reducing its tariffs on non-agricultural products as well as certain non-tariff barriers but moderate protection still persists which likely adds to the costs of intermediate inputs and, thus, to the hurdles faced by the Indian manufacturing sector.

#### **9.4.1 Characteristics of M3**

The study of Indian enterprises (denoted as M3 in this research) has revealed a comparative advantage in certain segments of the services sector but its services trade policy is still very restrictive, even as compared to China. The extent of liberalisation achieved so far and the outcomes it brought about suggest that the remaining goods and services trade barriers are just one item on the list of reforms that India needs to tackle in order to promote trade-led expansion of labour-intensive activities. Other important priorities include: reforming small scale industry policies that prevent realisation of economies of scale and productivity increases in the sector; relaxing of labour market rigidities that hinder the inter-industry and interstate labour mobility and underpin misallocation of resources across industries and states; tackling infrastructure bottlenecks; reducing regulatory differences across states.

Manufacturing sector is the backbone of any economy. It fuels growth, productivity, employment, and strengthens agriculture and service sectors. Astronomical growth in worldwide distribution systems and IT, coupled with opening of trade barriers, has led to stupendous growth of global manufacturing networks, designed to take advantage of low-waged yet efficient work force of India. But the enterprise models widely vary from sector to sector.

Indian Manufacturing Industry is successfully competing in the global marketplace and registering high growth on year to year basis, but large sections of 'Indian manufacturing' sector still suffers from bottlenecks like:

- Use of primitive technology or under utilisation of technology.
- Poor infrastructure.
- Over staffed operations.
- Expensive financing and bureaucracy.

Further, the Indian Manufacturing sector must focus on areas like improving the urban infrastructure, ensuring fair competition and access to markets, reduction of import duties, quality improvements in vocational and higher education, increased investment in R&D and support of SMEs. Government leaders, experts, and researchers are focusing towards

making Indian manufacturing globally competitive to have a sustained growth, which contributes significantly to GDP growth, employment generation and overall economic development. It also aims to identify factors hampering industrial growth and seeks to redress these factors.

On the other hand the service Sector in India today accounts for more than half of India's GDP. This marks a watershed in the evolution of the Indian economy and takes it closer to the fundamentals of a developed economy. This leads to a variance in service models as compared to manufacturing. Due to its own huge domestic market like China, a number of different enterprise models co-exist in India.

#### ***9.4.2 Application of POM to M3***

Arising out of the various discussions and subsequent case studies (Appendix-I) undertaken in India it is observed that global service sectors (BPO's) have more or less identical business models as compared to domestic sectors, whereas manufacturing models are sector-specific. Joint venture companies follow business models that are aligned to the parent companies. SME's has no set patterns and are mostly top driven. Due to the huge size of the domestic market, the modelling patterns vary widely among sectors, locations and individual enterprises. However due to a very competitive market, quality in products and services are highly valued. All the sub-models PCM, MM, KLSSM, GDM and DVCM with various combinations under the federated POM can successfully encompass most of the enterprise models in India.

### **9.5 How Pentatomic Organisation Model solves the problem?**

Most modelling methodologies orient themselves on the life-cycle concept but usually cover different parts of the life-cycle itself. In addition, additional terminology and sets of modelling constructs/language for representation of the modelling constructs are further obstacles to be overcome in the selection process (Table 9.1). Life cycle is a relative and application specific concept. Any modelling effort would need to look at an enterprise holistically in order to assess its existing IT and business change programs (AS-IS) against its future (TO-BE).



Enterprises in the 21st century demand constant change in order to adapt to the dynamic, global business environment. The success for the POM's will therefore depend on careful selection of the sub-models along with their combination and need-based deployment. Modelling is a continuous effort and not a one off exercise. Success will largely depend on the accurate assessment of the external business environment, business needs and customer requirements, strategy, cost and so on. Recent trend in organisation structures suggests a flexible architecture where need based changes can be easily embraced or adapted at an affordable cost and time frame with minimum disruption in operation. Organisation models are turning from orthodox command control hierarchical type to hyperarchical structure.

The IT revolution has inflicted revolution in traditional management thinking itself. Information moves up and down in gaps in hierarchical pyramids and each gap requires delay and effort therefore the challenge is sluggish response in hierarchical structures. The World Wide Web is an example of "hyperarchy" a more appropriate and responsive system. It is based on the notion of network centric methodology and results in more rapid and digestible change. Decentralised design enables more rapid adoption. Old organisational designs that rely on a top down centralised hierarchy cannot cope with the new business age and its dynamic nature. Speed and adoption are at the core of this new era and that is where the old design fails. Within a completely flat structure, all information on the Web is available to everybody anywhere in the world on 24/7 basis. Hyperarchical structure is the pattern of amorphous and permeable corporate boundary characteristics of the companies today.

The step by step approach to build an EA is not easy and quick. It requires careful consideration and capture of all pertinent information of the enterprise as a whole. Therefore commitment of senior management and involvement of all employees from various functional and professional backgrounds are mandatory for effective and meaningful outcome. Hence it is neither a band-aid solution nor a linear process since each of its phases may trigger further related changes. Therefore continuous evaluation, monitoring and feedback across the enterprise become very important. EA not understood by its people is a fruitless exercise. Therefore education and training related to the roadmaps for change is crucial. The EA transformation process for POM is no different than as prescribed in GERA.

<b>Model</b>		<b>Importance</b>	<b>Benefits</b>	<b>Condition of Use</b>
1.	<b>People-Centric Model (PCM)</b>	<b>Pivotal Role of People who are propelling force for any enterprise</b>	<b>Stimulated workforce not simply empowered workforce</b>	<b>This model is suitable mostly for Multi-National Enterprises (MNEs) with massive global operations supported by highly skilled trained workforce e.g. Energy, Gas &amp; Oil, Mining, Mega-Projects.</b>
2.	<b>Molecular Model (MM)</b>	<b>Business transaction is driven by human relationships and their sphere of Influence</b>	<b>Helps to analyse micro-architectural aspects towards enterprise engineering and integration efforts</b>	<b>This model is suitable for “holding” type of companies retaining core skills or business intelligence e.g. Trading companies, consulting etc.</b>
3.	<b>Kaizen-Lean Six Sigma Model (KLSSM)</b>	<b>Operational model for continuous improvement</b>	<b>Improving enterprise efficiency through proper allocation of skills, resource and information to people</b>	<b>Suitable for all types of businesses to embrace and manage change through wastage minimization, better customer satisfaction utilizing energized workforce</b>
4.	<b>Globally Dispersed Model (GDM)</b>	<b>Human Network of Networks through cyberspace</b>	<b>Collaborative and shared approach to resources, talent and customer management through enhanced ICT support</b>	<b>This model is more suitable for OEM, OBM and ODM type of companies. OEM: Original Equipment Manufacturer OBM: Original Brand Manufacturer ODM: Original Design Manufacturers</b>
5.	<b>Disaggregated Value Chain Model (DVCM)</b>	<b>Resembles atomic fission phenomena in value creation</b>	<b>Maximizing value creation through spirited approach to innovation, continuous improvement and change.</b>	<b>More suitable for complex networked organizations but not necessarily with intense high technology and requiring massive investment in IT</b>
6.	<b>Pentatomic organisation Model (POM)</b>	<b>Generic flexible &amp; expandable ‘system’ framework</b>	<b>With its common people-centric core, unification of sub-models becomes easier</b>	<b>The federated structure, with PCM as backbone, offers choice to both manufacturing and service industries.</b>

Table 9.1 Comparison of sub-models of Pentatomic Organization Model

In the fast changing business and information technology world, companies today, need to have a well thought out, documented, and communicated EA plan to ensure that the

enterprise captures a competitive advantage. Therefore drawing up an investment plan for achieving the future EA is always a moving target.

The Pentatomic Model (PM) could serve as a contemporary alternative to the traditional enterprise models. Table 9.1 summarises the importance, benefits and conditions of use for the five sub-models in Pentatomic Organization

Based on the literature review and the problems that were identified during field studies it was felt that new models are required to address the characteristics of the 21st century organisations. This does not, however, mean that organisational characteristics are only limited to five. Hence number of models for a given enterprise could be any number 'n' depending on the perception, need and choice of the modeller. That precisely is the reason for developing the Pentatomic Organisation Model (POM) under a "Federated System Framework" that is flexible and expandable. The unified and federated POM is thus capable of incorporating upcoming models in future through "On" or "Off" options. POM was subsequently applied to Signotron, India and further investigations are being continued in order to establish its credibility.

## **9.6 Future Research**

The future research on EA, EM and PO will continue to be influenced by a range of key considerations and developments in this century as summarised below.

### **9.6.1 *Pervasive computing***

Pervasive computing (also referred to as ubiquitous computing or ambient intelligence) aims to create environments where computers are invisibly and seamlessly integrated and connected into our everyday environment. Pervasive computing and intelligent multimedia technologies are becoming increasingly important, although many potential applications have not yet been fully realised. This upcoming technology will revolutionise today's concepts of enterprise modelling and the way businesses are run.

### **9.6.2      *Omnipresent society***

Organisations are social systems and governed by social and psychological laws. Organisation environment in a social system is dynamic. All parts of the system are interdependent. Transparent exchange of knowledge and information will create an omnipresent society; this signifies humanity's unification through the self-organisation of knowledge and information. This demands synthesis between values and needs resulting in a social system capable of accelerating the development of its individual parts.

### **9.6.3      *Atomised World***

Individual human atoms are migrating through web to form a liquid like structure that is capable of transforming into a solid structure as a tightly knit team; had they experienced a disaster, the forces that bind them would have weakened and they would disperse like gaseous atoms again to reform with other human atoms in a different situation.

Smart organisations require a new level of professionalism and sophistication in managing information exchanges since internetworking is squeezing out all the zero-value-added information, distortion, and ineffectual management activities.

Human atoms bring their brains, know-how, energy, and capacity for innovation. They also bring connections with customers, suppliers, and other partners. Therefore they are the most precious resource for any organisation.

### **9.6.4      *Future Enterprise Architectures***

Recent unified brain theory portrays brain as an inferential agent, continuously refining and optimising its model of the past, present and future. This can be seen as a generic process applied to all functions and protocols embedded in the brain; continually adapting the internal state of its myriad neural connections, as it learns from its experience. In the process it attempts to minimise the gap between its predictions and the actual state of the external environment on which its survival depends. Future enterprises, running under an architecture incorporating such ground breaking discoveries would put traditional notions upside down.

## **Chapter 10      Conclusion**

This research aimed to develop a universal set of enterprise models based on field studies in Australia, China and India that allows comparative analysis of enterprise practices, structures and work cultures. Built upon and shadowed under the traditional enterprise modelling approach, this research extends further into the unanswered issues of comparative modelling despite foreseeable influences and differences in political, socio-economic, business processes and other country specific factors. The research approach is to create flexible enterprise components and universally acceptable models that are simple, pragmatic and meaningful.

### **10.1 A universal modelling methodology**

This research develops POM as a unified model under the umbrella of a federated structure. As a concept the Pentatomic Organisation (PO) is only a step forward to the endless journey of Enterprise Architecture (EA) and Enterprise Modelling (EM). The universal modelling methodology for multi-country manufacturing systems analysis as adopted in this research is to carry out field studies and also discuss relevant modelling issues with the academics, peers and industry professionals in the respective countries that lead to the development of specific enterprise sub-models. Each of these sub-models becomes country-specific reference models. In other words the model characteristics are influenced by geographic, techno-economic, social and political factors that are country-specific. The very term universal in this case means applicable to all business irrespective of countries. Each business entity being unique cannot also be universal at the same time since the terms ‘unique’ and ‘universal’ are contradictory. Hence, the strategy of this research looks for commonalities rather than differences in modelling features and methodologies justifying the research methodology. Sub-models alone on their own, however, cannot explain the behavior of an enterprise as a ‘whole’ seamlessly that is why unification of the various sub-models becomes necessary.

### **10.2 Evaluating the Commonalities and differences**

Despite China and India being labour-abundant and dependent on manufactures, their export mixes are very different. Services exports are roughly twice as important for India as for

China, which is much better integrated into global production networks. Accelerated growth through efficiency improvements in China and India, especially in their high-tech industries, will intensify competition in global markets leading to contraction of the manufacturing sectors in many countries including Australia. However, without efforts to keep up with China and India, some countries may see further erosion of their export shares and high-tech manufacturing sectors.

There are very sharp differences in the trade patterns between Australia, India and China. Within merchandise trade, all are dependent on manufactures. However China is much more strongly integrated into production networks through trade in parts and components and their product mixes are radically different. Each country has undergone quite radical trade reform.

Improved growth in China and India will intensify competition in global markets and Australian manufactures are likely to be affected negatively. As China starts producing more sophisticated and new variety manufacturing products, there will be opportunities for Australia to expand their processing industries and this scenario will lead to severe competition in the high-tech sectors.

Australian businesses are characterised by:

- Concentration of small to medium sized enterprises;
- Small domestic market that limits opportunities for market testing and failure;
- Less than optimal levels of resourcing of trade, export or investment;
- Few Australian multinationals / global brands are particularly outside of the resources sector.

At the same time, Australia has advantages for engaging China and India – its natural endowment of the resources that both need, notwithstanding fundamental disagreements at times on significant social and political issues.

The continuing impact of China and India on Australia is undisputed, but the implications for Australia's approach to business opportunities with both of them need to be scrutinised more closely.

The key factors for Australian businesses engaging in China and India is success at capitalising on massive change, diversity and scale with agility and fast learning. Whatever be the particular business strategy, it must be able to deal well with cultural differences and an ambiguous, complex and volatile environment.

When the three country-specific models M1, M2 and M3 are compared the commonalities and differences observed are:

Commonalities:

- PCM and MM are applicable to and work well in all the three countries
- GDM is also applicable to all in varying degrees and is sector-specific
- DVCM works more for China and India as compared to Australia

Differences:

- KLSMM application produces mixed results. More applicable to Australia and India than in China

Thus the federated POM can be applied to all the three countries with appropriate mix of the five models PCM, MM, KLSSM, GDM and DVCM. The POM offers the scope to 'Add-On' new sub-models as required.

### **10.3 Discovering specific model characteristics**

People are the propelling force and play a pivotal role in any enterprise. Business transaction is driven by human relationships and through interaction of their sphere of influence. Therefore the business world may be perceived as a human network of networks through cyberspace. In other words it resembles atomic fission phenomena of value creation through interaction of individual sphere of influence. Maximising value creation through

spirited approach to innovation, continuous improvement and change are the typical characteristics of Pentatomic Organizations (PO's). Some of the challenges for the 21st century PO's would therefore be to model these generic facial expressions accurately to diagnose typical business problems and find their solutions. Australian industries need to take a much broader view along these lines and try to collaborate with countries like China and India based on commonalities rather than differences as it aspires to become more competitive in the global market.

Every enterprise is different. There is no enterprise modelling or architecture that can represent every individual enterprise. In the development of POM, consideration has been given to the fact that a flexible modelling approach should be adopted. Within POM, the sub-model PCM plays the pivotal role and the model emphasises the need for a stimulated workforce that delivers output to the customers with their skills (S) , resources both tangible and intangible (R) and real-time information (I). This sub-model in POM is suitable universally for all types of manufacturing and service industries. On the other hand, MM advocates that business transactions are always driven by human relationships and their respective spheres of influence and is suitable for holding type of companies with lean core in both manufacturing and service type industries. In that sense both PCM and MM are generic and universal. KLSSM is also applicable to all enterprises trying to improve their efficiency through proper allocation of skills, resource and information to people and is suitable for all types of businesses that are keen to embrace and manage change through wastage minimisation, better customer satisfaction utilising energised workforce. This sub-model is also universal in the sense that all business today needs to embrace change in order to survive under the constantly changing business environment. GDM basically demonstrates that all enterprises today are human network of networks through cyberspace and are therefore also universal and generic. This sub-model in POM is more suitable for OEM, OBM and ODM type of companies. DVCM on the other hand resembles atomic fission phenomena in value creation and co-creation and is suitable to all complex networked organizations. All these five sub-models PCM, MM, KLSSM, GDM and DVCM are unified and fit well into the POM which is a generic flexible and expandable federated 'system' framework with PCM as its backbone and offers country and sector-specific modelling characteristics.



## 10.4 Establish operational models

This research discovered that transparent exchange of knowledge and information will create an omnipresent society; this signifies Humanity's unification through the self-organisation of knowledge and information. The synthesis of human exchange results in a synthesis of values and needs, where one's needs are met by other's values and one's values meets other's needs. When individual interests integrate throughout the social whole and the interests of the social whole integrate with individual interests, this effectively allocates the human resource of knowledge and information throughout society, and inherently, the most effective solutions reach specific needs. Pentatomic Organisations (PO's) provide only a glimpse towards such omnipresent society. This research sees this emergent dynamic in 'open-source' collaborative efforts, which have the potential to address the collective needs of humanity through a Universally Integrated Societal model comprising of human network of networks.

PO's are social systems and governed by social and psychological laws. They have social roles and status. Their behaviour is influenced by their group's individual drives. Organisation environment in a societal system is dynamic. All parts of the system are interdependent. Organisations need people and people in turn need organisations.

This research demonstrated that POM could work as the universal operational model for manufacturing system analysis and helps to form international consortia to work effectively across businesses and cultural backgrounds through collaborative, resource sharing and gain-sharing partnerships across the borders. The country-specific five sub-models (PCM, MM, KLSSM, GDM and DVCM) under the federated structure of POM can be universally applied when looked through the lens of human integration and commonalities in modelling features. The concept of human sphere of influence, their interactions and the human network of networks are established in this research and corroborates with the case studies conducted in Australia, China and India.

## **10.5 Contribution to body of knowledge**

This research investigated the underlying principles of each of the five different portraits of PO's using enterprise modelling methodologies to provide a standard and universal process to analyse the five faces of the Pentatonic Organization (PO) by adopting an inductive research methodology following a two prong approach:

- Discussions with various academics, peers and industry representatives in Australia, UK, Germany, China and India
- Field study in Australia, China and India
- The research outcome has been the development of five new published models and a book chapter (Appendix II).

Practicing managers in the industry are by and large unfamiliar with the concept of enterprise modelling and its application as a tool to embrace change and cope with the complex business environment. These are the key reasons for low uptake of enterprise modeling by industry. These findings also corroborate with the global survey report by IFEAD and are one of the important contributions to the body of knowledge. The second contribution of this research is to develop five different enterprise models suitable for 21<sup>st</sup> century enterprises. A detailed step by step approach five different sub-models representing five different dimensions can pave the way for current and future modellers to develop various models as required for their specific needs. While five models characterise new dimensions of enterprise in the newly developed Pentatomic Model a modeller can choose and opt new other dimensions as needed. The federated structure thus offers flexibility to “Add-On” or “Delete” any specific sub-model as the external business environment changes. The implications of this research are that practicing managers have a new tool demonstrating a step by step approach to use this tool in addition to commonly used other popular tools.

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## Appendix – I

The various companies that were visited in Australia, China and India are listed below. This list of companies signifies that they were successfully negotiated in order to secure permission for conducting field studies and does not include many other companies who denied access to their factories.

Methodology adopted was to discuss with the respective CEO's, General Managers explaining the research questions and data required. Invariably the senior management was not very enthusiastic to give much time and so was the case with the middle managers and the operators. There were few exceptions such as in WorleyParsons, Melbourne where a field study was conducted lasting about a year.

Firstly enquiries were made in regard to existing enterprise models, product and or services, organisation structures, business processes and so on in order to determine the “AS - IS” model. Specific questions were asked in various group interviews in regard to the critical problems that the companies faced. They were analysed in the light of the literature review and possible solutions were suggested. In view of the time constraints and cost associated only those issues were selected that could produce quick at marginal cost for solving the problems with the “TO-BE” model. Since the nature of the problems and priorities were different for different companies only five new models could be developed and tried. In principle all the five newly developed models were successful and were subsequently published following the respective field studies. In some companies the new models are still being tried out such as Signotron.

### **In Australia:**

- Ford Motor Company ([www.ford.com.au](http://www.ford.com.au))
- Flowserve ([www.flowserve.com.au](http://www.flowserve.com.au))
- WorleyParsons ([www.worleyparsons.com](http://www.worleyparsons.com))
- Fallshaw Wheels and Castors ([www.fallshaw.com.au](http://www.fallshaw.com.au))
- National Australia Bank ([www.nab.com.au](http://www.nab.com.au))
- Mackay ([www.mackayrubber.com.au](http://www.mackayrubber.com.au))
- IBM Australia ([www.ibm.com.au](http://www.ibm.com.au))

### **In China:**

- Haier ([www.haier-elec.com.hk](http://www.haier-elec.com.hk))
- GEW Corporation ([www.gewcorp.com](http://www.gewcorp.com))

### **In India:**

- Development Consultants ([www.dcpl.net.in](http://www.dcpl.net.in))
- BCH limited ([www.bchindia.com](http://www.bchindia.com))
- Arctic Holdings ([www.arcticholdings.com](http://www.arcticholdings.com))
- Signotron ([www.signotron.com](http://www.signotron.com))

There are three key factors which determine the types of questions that researchers need to include in survey or interview questionnaires:

- Research question itself and the concepts it involves
- Mechanisms identified by researchers as links between variables
- Particular methods to be employed to analyse the data

The first two factors are closely linked. They deal with the researchers' own understanding of their project at the point where they actually begin gathering data. The third factor links these preliminary steps with the subsequent process of data analysis itself. In this regard, it is vital that researchers do not treat the issue of selecting a method of analysis as something decided after the data has been collected. Otherwise, they may find that the data they collect proves unsuitable for the type of analysis they eventually choose.

The deductive approach involves testing hypotheses, which have been derived beforehand from a general theory, against particular cases. The inductive approach follows a reverse process, assembling a general explanation from the data collected in the research.

Qualitative research is usually (though by no means always) aligned broadly with inductive methods. In such cases, the central focus is upon the context of the meanings people use to make sense of their immediate experiences. Accordingly, the aim is to resist setting the parameters of such projects prior to gathering the data.



A case study methodology is mainly used for:

- Experimental research-based projects.
- Analysis of real world problems of which one has experience or is able to observe.

The case study method involves detailed, holistic investigation (for example, all aspects of a company) and can utilise a range of different measurement techniques (the case study researcher is not limited to any one methodological tool). Data can be collected over a period of time, and it is contextual (relative to a certain industry).

The histories and stories that can be told about the company are also something that can be assessed and documented—not just empirical data, for example, how the company interacts with the marketplace can be used.

Literature review revealed that the four internationally recognised existing Enterprise Architectures (EA's) were CIMOSA (Computer Integrated Manufacturing Open System Architecture), PERA (Purdue Enterprise Reference Architecture), GIM (GRAI Integrated Methodology) and GERAM (Generalised Enterprise Reference Architecture and Methodology). It was further observed that these EA's had shortcomings being static and was mostly Information Architectures for Computer Integrated Manufacturing (CIM). A holistic and multi-disciplinary approach was lacking and very few industrial applications /case studies were available. Most modelling methods were found unsuitable for service industries such as consulting firms, healthcare and banking etc and could not address modern business complexities. On top of these the modelling methods were too complex to understand and were full with information silos.

In order to overcome these problems the author decided to investigate the concept of enterprise modelling and usage of EA's among various industries in Australia, India and China.

The research methodology as adapted is shown in Figure 1.

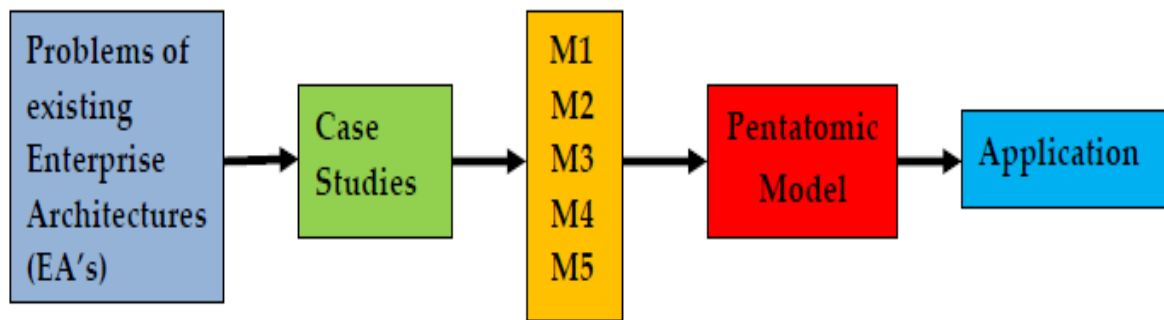


Figure 1 Research Methodology

This methodology was selected after establishing the gap between the literature review and the experience gained during preliminary investigations with the local industries in Australia.

In this qualitative research, using an inductive methodology, a generic questionnaire was designed to collect research data.

Generic Questionnaire:

1. Are you aware of Enterprise Modelling?
2. Could it be used as a tool to improve productivity?
3. Do you have an enterprise or business architecture?
4. Are you familiar with “AS-IS” and “TO-BE” enterprise models to answer “What if scenarios”
5. How much percentage (approximate) of your business processes is automated?
6. Do you have a plan to upgrade your IT infrastructure?
7. How your business processes support customer and their needs?
8. Would you be willing to try out new models to improve your business?
9. Do you have an existing business process map?
10. What you expect from enterprise modelling when used as a tool?

While developing five new enterprise models between Chapter 3-7 these questions were asked to the CEO’s/General Managers or Head of Operations of the respective companies where case studies were undertaken. In fact literature review, model

conceptualisation/development and data collection were undertaken concurrently while establishing the framework for the backbone model PCM (Chapter 3) shown as M1 in Figure 1. The other models between Chapter 4 to 7 are represented as M2, M3, M4 and M5. These five models were developed after identifying the research gaps between literature reviews, traditional reference architectures and indicating the contributions made. Knowledge gained during the development of these five models also served as the underpinning research data leading to the Pentatomic Model in Chapter 8. The linking of the five sub-models to the federated structure of Pentatomic Models has been explained in details in this chapter (Figure 8.5).

Since all these models can be mapped against GERA automatically validates them as shown in Figure 2.

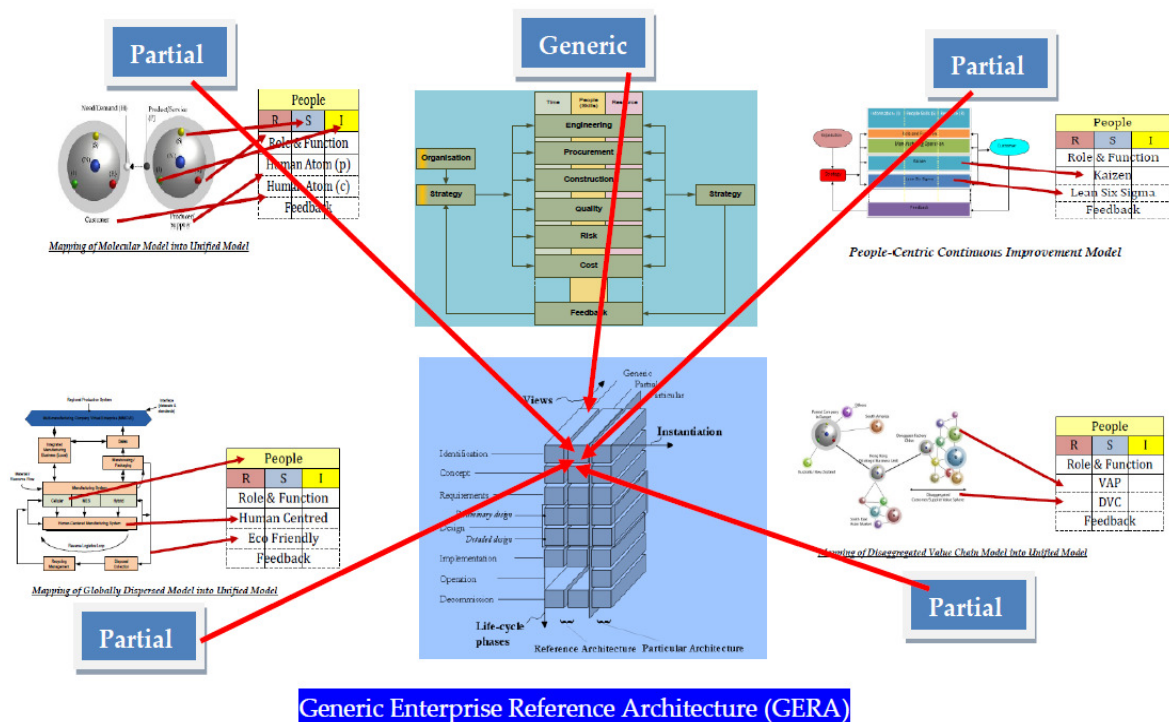


Figure 2 Mapping against GERA

The case study conducted in Signotron India ([www.signotron.com](http://www.signotron.com)) had shown that using Pentatomic Model, the company was able to enlarge their market share by 8% and increase 9.1% cash savings through productivity gains. It also helped them to improve business strategy in line with the customer expectations.

Molecular Model has helped to monitor individual / team performance and cost of operation.

The Globally dispersed Model is currently not applicable to Signotron since their global operation is still in very low key. The Disaggregated Value Chain Model is very useful for their intimate and trustworthy relationships with suppliers. The Kaizen-Lean Six Sigma Model partly used. They cannot afford to employ a Six Sigma Black Belt but have embraced Kaizen and Lean Philosophy. Research data collection is still being continued at Signotron

The limitation of this research is in the case studies of each application for five different models. The case studies do not explicitly describe adequate performance data thereby limiting evidence for validation. This is due to the limited scope of the qualitative research that was undertaken and the time constraint as was required for detailed validation by performance measurement. It was further observed during the field studies that all most all industries were very sensitive to allowing performance measurements and share data (except for the Pentatomic Model case studies at Signotron).

## Appendix - II

### **List of publications till date:**

1. Chattopadhyay, S. (2010a). The Atomic Views of Flat Supply Chains in China. *International Journal of Engineering Business Management*. Vol. 2 (2). pp 67-76
2. Chattopadhyay, S., Mo, J.P.T. (2010b). Modelling a Global EPCM (Engineering, Procurement and Construction Management) Enterprise. *International Journal of Engineering Business Management*. Vol. 2 (1). pp. 001-008.
3. Chattopadhyay, S., Mo, John P.T. (2010c). Pentatomic Organization. The new faces of organizations in the twenty-first century. Chapter 17. Vol.1. ISBN 978-0-9865335-0-1.
4. Chattopadhyay, S., Chan, Danny S.K., Mo, John P.T. (2010d). Modelling the disaggregated value chain – the new trend in China. *22nd Annual Conference of the Association for Chinese Economic Studies Australia*. Melbourne, Australia 15-17 July.
5. Chattopadhyay, S., Chan, Danny S.K., Mo, John P.T. (2010e). Development of a model for molecular organizations: Insights from chemistry. *International Journal of Management*. Dec 2011, Vol. 28(4). (To publish).
6. Chattopadhyay, S., Chan, Danny S.K., Mo, John P.T. (2010f). Business Model for Virtual Manufacturing - A human-centered and eco-friendly approach. *The International Journal of Enterprise Network Management*. Vol. 4 (1). pp 39-58.
7. Vella, R., Chattopadhyay, S., Mo, J.P.T. (2009). Six Sigma Driven Enterprise Model Transformation. *International Journal of Engineering Business Management*. Vol.1(1). pp1- 8.

## **Appendix III: Acronyms & Glossary**

### **Acronyms**

**BPR** Business Process Reengineering

**C4ISR** Command, Control, Communications, Computer, Intelligence, Surveillance and  
Reconnaissance Architecture Framework

**EA** Enterprise Architecture

**ICAM** Integrated Computer Aided Manufacturing

**ICOM** Inputs, Controls, Outputs, and Mechanisms

**IDEF** Integrated Computer Aided Manufacturing Definition Language

**IT** Information Technology

**QA** Quality Assurance

**RM** Risk Management

**TQM** Total Quality Management

**WBS** Work Breakdown Structure

**BOM** Bill of Materials

**B2B** Business-to-Business

**B2C** Business-to-Consumer

**CAD/CAM** Computer-Aided Design/Computer-Aided Manufacturing

**CEO** Chief Executive Officer

**CIM** Computer Integrated Manufacturing

**CIMOSA**

**CRM** Customer Relationship Management

**CSF** Critical Success Factor

**DSS** Decision Support System

**EDI** Electronic Data Interchange

**ERP** Enterprise Resource Planning

**GERAM**

**GRAI-GIM**

**IBM** International Business Machines

**I/O** Input/Output

**IS** Information System

**ISO** International Standards Organization

**IT** Information Technology

**LAN** Local Area Network

**MRP** Materials Requirements Planning

**PERA**

**SOA** Service Oriented Architecture

**WWW** World Wide Web

## **Glossary**

**“As-Is” Architecture** The current state of an enterprise’s architecture

**“To-Be” Architecture** The target state of an enterprise’s architecture

**Architectural Artefacts** The relevant documentation, models, diagrams, depictions, and analyses, including a baseline repository and standards and security profiles.

**Architecture Repository** An information system used to store and access architectural information, relationships among the information elements, and work products.

**Artefact** TEAF An abstract representation of some aspect of an existing or to-be-built system, component, or view. Examples of individual artefacts are a graphical model, structured model, tabular data, and structured or unstructured narrative. Individual artefacts may be aggregated.

**Architecture Framework** An organizing mechanism for managing development, maintenance, and facilitated decision making. The Framework provides a structure for organizing Federal resources and for describing and managing Federal EA activities.

**Business Architecture** A component of the current and target architectures and relates to the Federal mission and goals. It contains the content of the business models and focuses on the Federal business areas and processes responding to business drivers. The business architecture defines Federal business processes, Federal information flows, and information needed to perform business functions.

**BI portals:** BI Portal is about centralizing all the organizational knowledge in one place, thus making it effortlessly available to all designated end-users. BI Portal efficiently provides end users with a unified environment which contains all the key business information they need, thus improving accessibility, increasing productivity and optimizing organizational decision making processes.

**B2B:** Short form for business-to-business, the exchange of services, information and/or products from one business to another, as opposed to between a business and a consumer

**CIMOSA** Computer Integrated Manufacturing Open System Architecture is an enterprise modeling framework, which aims to support the enterprise integration of machines, computers and people. The framework is based on the system life cycle concept, and offers a modelling language, methodology and supporting technology to support these goals.

**Components** Representation of a desired state for all or part of the enterprise for an interim milestone between the baseline architecture and the target architecture. A time-sliced set of models that represent the increments in the sequence plan.

**DNA (deoxyribonucleic acid):** is a double-stranded molecule that is twisted into a helix like a spiral staircase. Each strand is comprised of a sugar-phosphate backbone and numerous base chemicals attached in pairs.

**Enterprise** An organisation supporting a defined business scope and mission. An enterprise is comprised of interdependent resources (people, organizations, and technology) that should coordinate their functions and share information in support of a common mission (or set of related missions).

**Enterprise Architecture (EA)** A strategic information asset base, which defines the business, the information necessary to operate the business, the technologies necessary to support the business operations, and the transitional processes necessary for implementing new technologies in response to the changing business needs. It is a representation or blueprint.

**Enterprise Engineering** A multidisciplinary approach to defining and developing a system design and architecture for the organization.

**Enterprise Life Cycle** The integration of management, business, and engineering life cycle processes that span the enterprise to align IT with the business.

**GERAM** Generalised Enterprise Reference Architecture and Methodology (GERAM) is a generalised Enterprise Architecture framework for enterprise integration and business process engineering. It identifies the set of components recommended for use in enterprise engineering

**GRAI-GIM** A modelling methodology intended for general description, focused on details in manufacturing control system.

**Methodology** A documented approach for performing activities in a coherent, consistent, accountable, and repeatable manner.

**Model** Representations of information, activities, relationships, and constraints

**Monolithic Organization:** Organization large, powerful, indivisible, and slow to change



**PERA** The Purdue Enterprise Reference Architecture (PERA) and its accompanying Purdue Methodology were developed at the Purdue University, USA. This university took a leading role in the definition of reference models for computer integrated manufacturing as well.

**Portals** Portal is a term, generally synonymous with gateway, for a World Wide Web site that is or proposes to be a major starting site for users when they get connected to the Web or that users tend to visit as an anchor site. There are general portals and specialized or niche portals. Some major general portals include Yahoo, Excite, Netscape, Lycos,

**Repository** An information system used to store and access architectural information, relationships among the information elements, and work products..

**Systems Development Life Cycle (SDLC)** Guidance, policies, and procedures for developing systems throughout their life cycle, including requirements, design, implementation, testing, deployment, operations, and maintenance.

**Vortals:** Vortals, or vertical portals, function like portals in that they serve as Internet starting points. Unlike portals vortals serve narrow and well-defined interests. A vortal provides, internet users with a route to content, that is relevant to their specific interest. Through a careful selection of content and links to other Web sites, vortals focus in on a particular slice of the Internet. Some vortals serve specific communities and social groups. Other vortals are focused on hobbies and special interests.

**Zachman Framework** Classic work on the concepts of information systems architecture that defined the concept of a framework and provided a 6x6 matrix of architecture views and perspectives with products.